Introduction to Prospecting

By E. L. Faulkner

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Ministry of
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Hon. Jack Davis, Minister

GEOLOGICAL SURVEY BRANCH
MINERAL RESOURCES DIVISION

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a properly completed tag.

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INTRODUCTION

"Introduction to Prospecting" began as a series of notes intended to accompany a basic prospecting course. It quickly became apparent that there was a need for a more complete text, not only for such courses, but also for the many general readers interested in prospecting as a hobby or part-time pursuit, and for those unable to attend introductory prospecting courses.

The first four chapters deal with the identification of rocks and minerals. These are followed by chapters giving basic geological information and describing mineral deposits. Also covered are mining, claim staking and legal requirements, and geochemistry and geophysics. Three other chapters have been enlarged: they are Chapter 8 — Fieldwork — because individual backgrounds and knowledge vary so greatly, Chapter 11 — Placer Deposits — because of the widespread interest in placer mining in this province, and Chapter 12 — Preparing Claims and Making a Deal — because this is so important to the outcome of a prospector's hard work. Eight of the chapters have Additional Notes; I suggest you omit these on your first reading. When you have dealt with the subject matter of the chapter, you can read the Additional Notes if you need further details or additional information.

I strongly urge you to take a basic prospecting course if at all possible. If not, try to take a short course in rock and mineral identification — such courses are periodically available in some cities. There is no substitute for the personal contact and laboratory practice that a good course provides. Failing this, sets of rocks and minerals suitable for self study may be purchased from any District Geologist's office. Instructors using this book as a course text will note that the first four chapters are brief; the sessions should obviously concentrate on laboratory demonstration and practice. Other chapters are self-contained and can be supplemented by appropriate laboratory work and additional practice on rock and mineral identification, or left for the students to read, depending on the course structure.

I would like to express special thanks to the many students in my prospecting classes over the years who have said that I should write a book on prospecting. So many individuals, prospectors, friends, and colleagues in the Ministry and in industry have contributed to this book in some way that to acknowledge them individually would require a long list. It would also risk inadvertently omitting a name that should be included. To all those who have contributed to the content or production of this book I extend my sincere thanks and appreciation.

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CHAPTER 1 — MINERALS

INTRODUCTION

A mineral is a naturally occurring chemical compound. Most minerals have a definite composition, with fixed percentages of two or more of the many different elements that occur in the earth's crust. Some minerals have compositions which can vary, but only within fixed limits. A few minerals, like gold, contain only one element. A mineral has a generally fixed composition because it has a definite molecular structure. This in turn means that each mineral will have its own characteristics which can be used to make identifications.

There are well over 2 000 known minerals, but fortunately for us only a small percentage of them are common, or are of interest to prospectors. Even so, this small number may seem confusing and difficult to tell apart for the beginner. The secret of success in mineral identification is *practice* and *patience*. Start by recognizing the easy ones, then gradually add the not-so-easy ones, and remember that even experts may not always be able to identify minerals just by "looking at" them.

Minerals are important to the prospector for the following reasons:

(1) They are the ingredients of which all rocks are composed, and it is important for a prospector to be able to identify common rocks.

(2) They form mineral deposits, which may have economic value. The aim of prospecting is to find economic mineral deposits.

We identify minerals in the field by making use of their characteristic or "key" properties, and sometimes by making very simple chemical tests. The characteristics which are of most value to us will be described in Chapter 2, with some brief explanatory notes. These characteristics are best explained and demonstrated in a prospecting course or a course on mineral and rock identification.

MINERAL PROPERTIES

Many books have been written that describe the properties of minerals and classify minerals in various ways. Unfortunately, most tend to be too technical for a beginner to use and usually go into more details than a prospector ever needs to know. However, with the information given in the first two chapters of this book, and some practice, you will be able to use some of the available books as references to check the properties of common minerals or to help with the identification of unusual minerals. While it is nice to have a reference book around, you do not want to be burdened with carrying more material than necessary once you are out prospecting or to spend time thumbing through books, so try to develop your mineral identification skills as much as possible.

Once you understand the properties of minerals which follow, get into the habit of using them in a systematic manner. Even if you think you know what a mineral is at first glance, always check its key properties. Every practicing geologist can tell you stories about people who made mistakes or missed something important because they misidentified a mineral and did not check to make sure what it was.

EQUIPMENT FOR MINERAL IDENTIFICATION

You will need a few simple items of equipment to help you with mineral and rock identification (Fig. 1-1):

(1) Penknife.
(2) Ten power (× 10) hand lens.
(3) Magnet.
(4) Streak plate.
(5) A small plastic bottle of dilute hydrochloric (muriatic) acid.

The use of these items will be described in the appropriate sections which follow. If you are taking a prospecting course, you may receive some of these items with your course materials. If not, all except item No. 1 can be purchased at any District Geologist's office.

COLOUR

Colour is one of the obvious things which we notice about a mineral, and it can be one of the most valuable properties a mineral has for its identification. If a mineral has a fixed chemical composition and is usually free of impurities, then it will have a characteristic colour. In this case, the colour will be valuable for identification purposes. If the mineral has a composition which can vary, or if it tends to have impurities in it, then the colour may vary and be less useful, or possibly of no use for identification purposes. Concentrate first on those minerals that have a characteristic colour.

STREAK

The **streak** of a mineral is its colour when it is crushed into a fine powder. It is usually observed with the aid of a **streak plate**, which is a piece of hard white unglazed tile. The mineral is rubbed on the streak plate and the colour of the trace or streak made on the tile is observed.

The streak of mineral grains that are too small to rub on a streak plate can also be observed if you carefully crush or scratch the mineral with your penknife, and look at the powder produced with your magnifying glass.

Minerals that give useful streak colours are usually dark or strongly coloured and are often heavy for their size. Lightly coloured minerals and almost all of those that form the common rocks do not give useful streaks, because the streaks are mostly white.

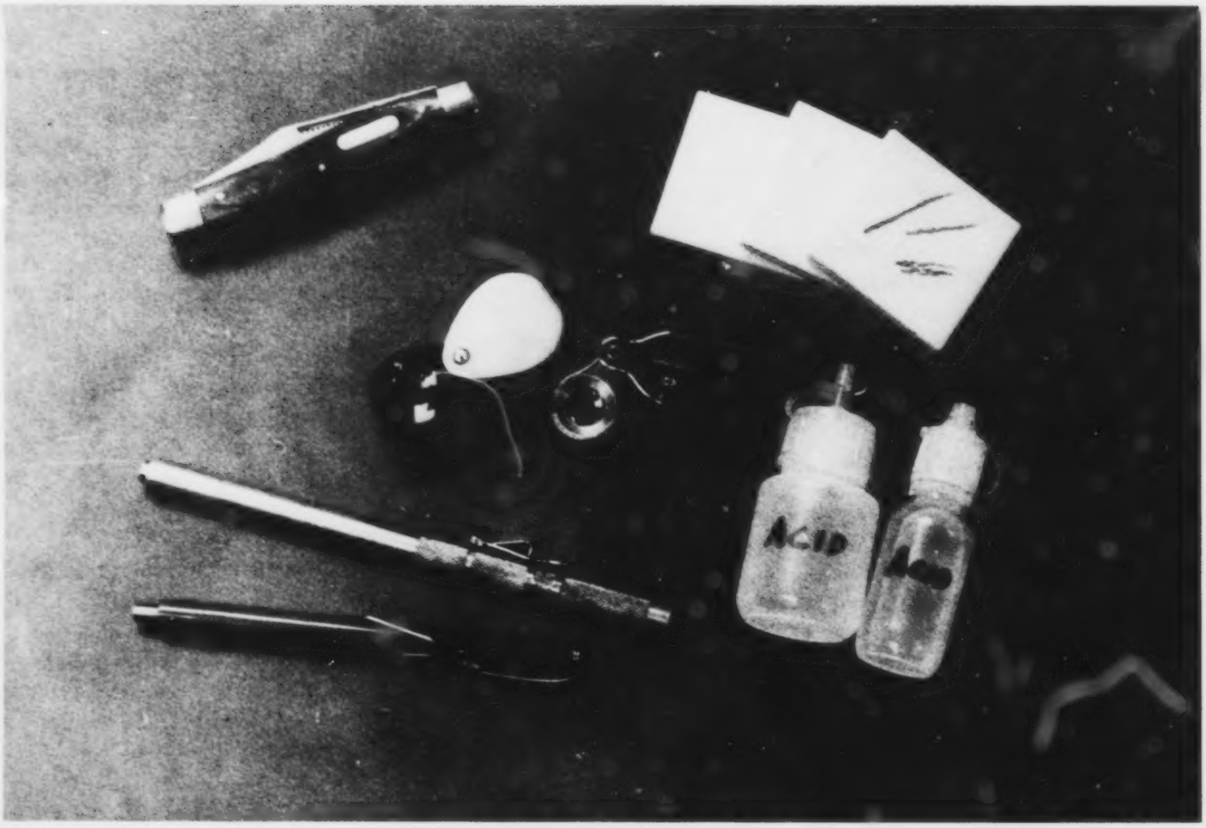


Figure 1-1. Basic equipment for mineral and rock identification. (Clockwise from top left: penknife; streak plates; two styles of acid bottle; two popular types of pencil magnet. Centre: two low-cost × 10 hand lenses.)

The streak of a mineral may be the same colour as that of the mineral itself (but usually of a lighter shade) or it may be quite different. Usually the streak is more dependable, or shows less variation, than the actual colour of the mineral.

FORM

The form of a mineral describes the usual appearance of most specimens of that particular mineral. **Crystalline** means the specimen is made up of groups of crystals. **Granular** means the specimen is made up of small rounded or shapeless crystals or grains. **Earthy** means the specimen is like hard dried clay (but not necessarily the same colour). **Massive** means the specimen is just a mass without other particular characteristics. Many other terms used to describe form, such as **powdery**, **flaky**, and **fibrous**, are self-explanatory.

CRYSTAL FORM

Crystal form is, simply, the shape of a crystal. The term refers to the geometrical shape which results when a mineral grows and it is controlled by the molecular structure of the mineral. Under ideal conditions almost all minerals form crystals but, under natural conditions, where minerals have to compete for space while they grow, most minerals do not form good crystals or they may be mixed in with other minerals and the crystal form is not readily seen.

Crystals can be divided into six major families or groups, each group having certain combinations of geometrical shapes. A proper understanding of crystal form requires a knowledge of geometry which few of us have, but fortunately we can get by without getting into great detail.

(1) A mineral may or may not form good crystals in nature. It is more important to know those few minerals that tend to occur as good crystals, than it is to be able to understand details of the geometry.

(2) If a mineral forms crystals, the shape and size of individual crystals may vary, but the angle between corresponding crystal faces is constant and characteristic of that mineral.

CLEAVAGE

Some minerals have planes of weakness in their molecular structures and tend to break along these planes. We call these **cleavage planes** or **cleavages**. They may have one, two, three, or more directions of cleavage, although it is often difficult to count the exact number of cleavages. Other minerals do not have any cleavages at all and tend to break irregularly.

Most beginners have some trouble telling the difference between crystal surfaces and cleavage surfaces. Remember that crystal form is an *external* feature of a mineral, whereas the cleavage, if any, is *internal* and can only be observed by breaking the mineral or by looking at a broken surface.

As a general rule, cleavage faces are usually *smoother*, *shinier*, and *cleaner* than crystal faces. You can often tell if a mineral has cleavage, even if it is present as small grains, by turning the specimen in different directions in sunlight or under a bright artificial light. Cleavages on the broken surface will reflect this light and the specimen will sparkle (Fig. 1-2).

LUSTRE

The lustre or "shine" of a mineral depends on the nature of the surface of the mineral and the way it reflects light. The following terms are used to describe lustre and are mostly self-explanatory: **dull, earthy, greasy, glassy, silky, resinous,** and **metallic**. Another term you may see — **adamantine** — means to sparkle or shine like a cut gem.

LIGHT PENETRATION

Three terms are used to describe light penetration:

Transparent — This means that light will pass through the mineral with very little distortion.

Translucent — This means that light will penetrate the mineral, but is distorted; you cannot see clearly into or through the specimen.

Opaque — This means that light will not penetrate the mineral at all.

To check for light penetration, look at a sharp edge or small chip of the mineral against a good light.

DENSITY

This term describes the weight of the mineral specimen compared to the weight of an equivalent volume of water. Thus a mineral with a density of three will always weigh three times as much as the same volume of water. (Strictly the term should be specific gravity, and you will see this term, or the abbreviation S.G., in textbooks; however, most people have a better understanding of what "density" means). Do not confuse density with weight; the question to ask is whether the specimen is heavy or light *for its size*.

As a guide, the density of most common rocks is between 2.75 and 3.25. A little practice will soon give you a "feel" for the density of a mineral if the specimen is reasonably pure and large enough for you to heft.

HARDNESS

Properly applied, the hardness of a mineral is one of the more useful properties for the identification of minerals. For comparison purposes, we use Mohs' scale of hardness, which is a scale of hardness using certain common or important minerals as standards. Remember that the scale is relative; thus a mineral of hardness five will scratch any mineral with hardness less than five and be scratched by any mineral with hardness greater than five.

Mohs' Scale of Hardness

(hardest) 10 = Diamond
9 = Corundum
8 = Topaz
7 = Quartz
6 = Feldspar
5 = Apatite
4 = Fluorite
3 = Calcite
2 = Gypsum
(softest) 1 = Talc

Some other useful hardnesses are: fingernail = 2.5, copper penny = 3, penknife = 5+ (depends on the steel), file or tool steel = 6.5, and glass = 5.5.

A little practice will develop a feeling for mineral hardness, but the following are four practical tips for testing hardness:

(1) If you do not appear able to scratch a mineral with your penknife, try to scratch the penknife blade with the mineral — reversing the test. If the mineral is harder, it will mark the penknife.

(2) You may leave a metal smear on very hard minerals when you try to scratch them, and you might mistake this smear for a scratch. If you reverse the test, the mistake will be obvious.

(3) Some hard minerals in the form of small loosely cemented crystals or small grains may appear to scratch easily with a penknife. What you may be doing is just separating the mineral grains rather than scratching them. Again, reversing the test will show if this is the case.

(4) Some minerals may be weathered or altered on the surface. Be sure you are testing the hardness of the mineral itself and not just scratching some coating on the surface.

MAGNETIC RESPONSE

A few iron-bearing minerals are magnetic and many other minerals may contain these magnetic minerals as impurities, and thus appear to be magnetic themselves. A magnetic mineral will give an even magnetic response regardless of where you test the specimen with your magnet. Minerals with magnetic impurities usually give a magnetic response which varies from place to place on the specimen.

REACTION WITH ACID

Some minerals react with dilute acid and their response to an acid test will help to identify them. The acid commonly used is dilute (10 per cent) hydrochloric acid. This acid is sometimes sold in hardware stores under the name "muriatic acid". *Carefully* pour one part of the concentrated acid into nine parts of water and mix. A special plastic acid bottle that

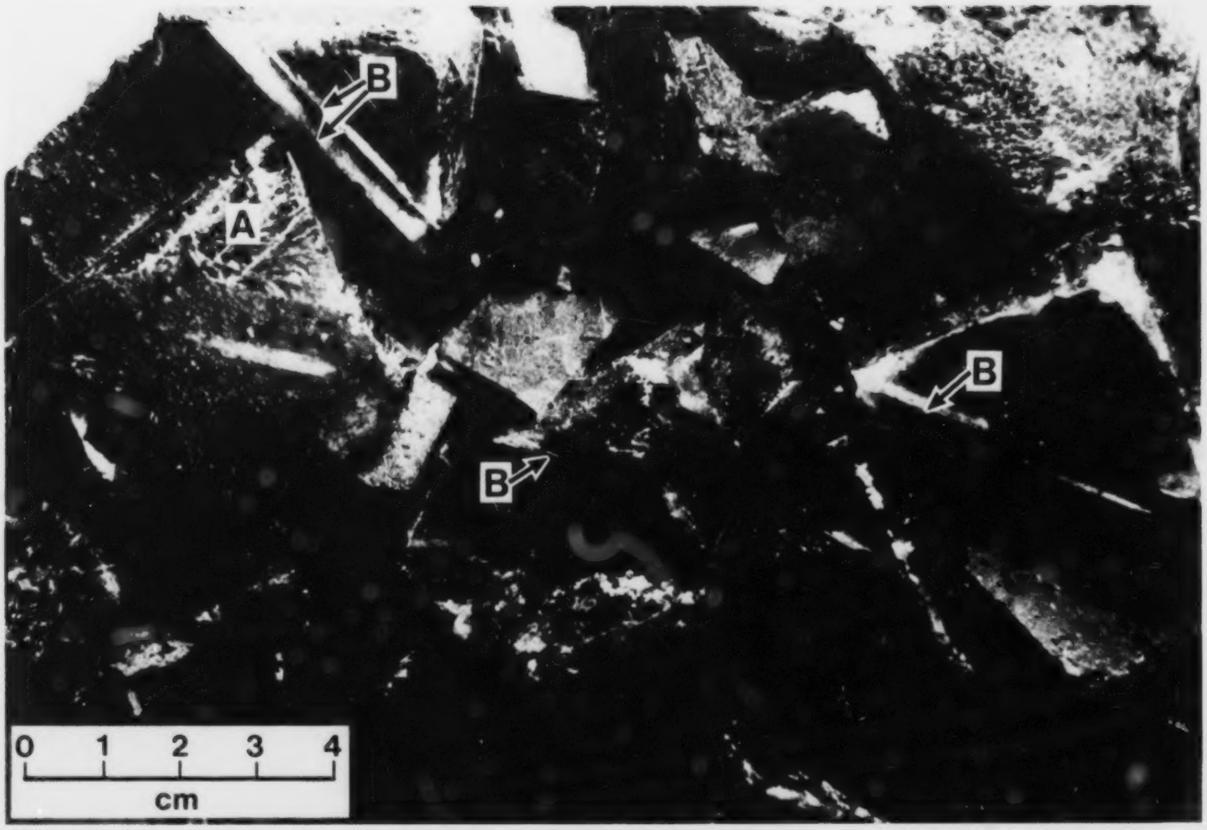


Figure 1-2. Cleavage and crystal form. This specimen shows several large cube-shaped crystals of fluorite. A corner of one crystal has been broken off revealing a shiny internal cleavage plane (A). Light can also be seen reflecting off cleavage planes inside other crystals (B).

will dispense acid a drop at a time should be used to carry the acid in the field.

The acid is used to detect and identify **carbonate** minerals and some **sulphide** minerals. To test, simply put a drop of acid on the specimen and see if it fizzes. If there is little or no reaction, first check for bubbles with your magnifying glass. Then scratch through the drop of acid with the blade of your penknife (or put a drop of acid on a fresh scratch). Some carbonate minerals will react only if they are powdered, as in a fresh scratch. A few sulphide minerals will react with this acid to give a slight rotten egg smell.

OTHER PROPERTIES

There are many other properties of minerals, but they tend to be of little value in identifying the majority of minerals. Some of these other properties, such as radioactivity and ultraviolet light response, will be described in Chapter 10, but here are three worth a brief mention:

(1) Tarnish — This refers to a film or coating on a mineral, often coloured, which usually results from exposure to weathering. Tarnish may obscure the true colour or hardness of a mineral.

(2) Play of Colours — This term is properly called **schiller**, meaning to shine, and refers to a "play of colours" or iridescence sometimes seen on a few minerals. The effect is much like the colours seen when a drop of oil is put on a water surface.

(3) Striations — This is a term meaning "scratches" and refers to what look like closely spaced parallel lines sometimes seen on crystal or cleavage surfaces. They result from the way a few minerals grow and are occasionally useful in identification.

CHAPTER 2 — MINERAL IDENTIFICATION

INTRODUCTION

On the mineral identification table which follows (Table 2-1), you will find a list of common and important minerals. Under the various headings, H stands for hardness and D for density or specific gravity. As far as possible, numbers have been rounded off and details kept to a minimum. Some Additional Notes on mineral identification follow. Do not worry about these for the moment.

How much of this information should you learn? Obviously you can refer to the table all the time if you do not mind carrying it around. However, every mineral usually has one, two, or three physical properties which are especially important or characteristic of that mineral and distinguish it from all the others on the list. These can be called the "key" properties, and they have been printed in bold type in the table. You should try to learn these key properties, which is a much easier task than trying to memorize the entire table.

When identifying a mineral specimen, if you have an idea what it might be, *check the key properties*. If they do not fit, then you must try another mineral. If they do fit, then you can check the answer by seeing if the other non-key properties also fit.

ADDITIONAL NOTES

MINERAL IDENTIFICATION

There is no "ideal" format for a mineral identification table, and minerals can be grouped in different ways, each with advantages and disadvantages. For example, arranging the minerals alphabetically as has been done here, makes them easy to locate, but it tells you little about what types of rocks or mineral deposits they occur in. Table 4-3 is a checklist of the minerals that provides some information on their occurrence.

There are many schemes for mineral identification, but they are seldom designed for the beginning prospector. Be careful with schemes that use only the same one or two properties for the identification of all minerals. They assume you will be very good at determining the chosen properties or have the laboratory equipment to determine properties such as specific gravity. Geologists do not rely on the same few properties for the identification of all minerals and neither should you; use the key properties.

GOLD AND FOOL'S GOLD

The key properties of gold and the two minerals that are referred to as "fool's gold" are set out in the following table:

Mineral	Colour	Streak	Hardness
Gold	"Gold"-yellow	"Gold"-yellow	Soft and sectile
Pyrite	Pale yellow	Black	6 and brittle
Chalcopyrite	Brassy yellow	Greenish black	3.5

The colour of gold is distinctive, and a paler yellow than jewelry gold. **Sectile** means that the gold cuts like plastic rather than powders or splinters under your penknife blade.

Sometimes wet and partly weathered biotite flakes can look deceptively like gold specks, especially in a gold pan. A careful check with your magnifying glass should spot the mica cleavage, while in a gold pan mica flakes will come to the top.

The old prospector's saying that "if you can see it, it ain't gold" has some merit, and reflects the rarity of gold. When gold is present it may be invisible to the eye or magnifying glass; the only way to confirm its presence and to find out how much is there will be to have the material assayed (*see* Chapter 6).

IMPORTANT SULPHIDE MINERALS

The following sulphide minerals are found in many types of mineral deposits, and often two or more occur together. Here are their key properties:

Mineral	Colour	Streak	Hardness	Other
Chalcopyrite	Brassy yellow	Greenish black	3.5	—
Pyrite	Pale yellow	Black	6	—
Pyrrhotite	Bronze	Black	4	Moderately magnetic
Sphalerite	Yellow-brown to black	Pale yellow to yellow-brown	3.5	Several directions of cleavage

IDENTIFICATION OF FELDSPARS

Feldspars are the most common of the silicate minerals and, because of this, the identification of some rocks depends on being able to identify the types of feldspar present. It is sufficient if you can identify a mineral as a feldspar, but some of you may wish to try to identify the type. This is difficult to do in the field without tests, and the following steps are not foolproof. They will give you the right answer perhaps four out of five times.

(1) All feldspars must have **H = 6** and **two cleavages at 90 degrees**. To proceed further, the crystals must be large enough to examine carefully with your magnifying glass.

(2) If you can see **striations**, call it **plagioclase**. If not, call it **potash feldspar**.

For the potash feldspars only:

(3) If it is a **pale flesh-pink** or **flesh-brown** colour, call it **orthoclase**.

(4) If it is a **pale apple-green**, call it **microcline**.

In rocks, feldspars are likely to be confused with quartz, and the finer the grain size, the more likely feldspar is to be mistakenly identified as quartz. The following points may be of help.

(1) On a fresh surface and a weathered surface, quartz is likely to appear dull, grey, and glassy.

(2) On a fresh surface, feldspar is likely to appear pale or weakly coloured (greyish or whitish) and splintery.

(3) On a weathered surface, feldspar is likely to appear opaque and powdery. You should be able to scrape off some of this powdery coating with your knife.

TABLE 2-1. MINERAL PROPERTIES:

Mineral (Group)	Comment	Composition	Colour, S = Streak	Lustre
Arsenopyrite	sulphide	iron-arsenic sulphide	**silver-grey**, S = black	metallic
Azurite	weathering product	hydrated copper carbonate	**blue**	earthy
Barite	industrial mineral	barium sulphate	**white, off-white**	glassy, pearly
Bornite	copper ore	copper-iron-sulphide	**red-brown**, S = grey-black	metallic
Carbonates	mostly rock-forming minerals	calcite = $CaCO_3$, dolomite = $(Ca, Mg) CO_3$, siderite = $FeCO_3$	white, grey, earthy	dull
Chalcopyrite	copper ore	copper-iron sulphide	**brassy yellow, S = greenish black**	metallic
Chromite	chromium ore	chromium-iron oxide	**black, brown-black, S = brown**	**dull to poor metallic**
Cinnabar	mercury ore	mercury sulphide	**scarlet to red-brown, S = scarlet**	dull to metallic
Dark Minerals (Augite and Hornblende)	rock-forming silicates	complex iron-magnesium minerals	**greenish, greenish-brown to black**	glassy, dull
Feldspar Group	rock-forming silicates	potassium silicates, sodium silicates	pink, brownish, greenish, off-white, white, grey, blue-grey	glassy to pearly
Galena	lead ore	lead sulphide	**lead-grey**, S = grey-black	metallic
Garnet	rock-forming silicate	complex silicate	usually reds, browns, black, green	glassy
Gold	metal	impure gold	**"gold"— pale yellow**	metallic
Gypsum	rock-forming mineral	calcium sulphate	**white or off-white**	dull to glassy
Hematite	iron ore	iron oxide	**red-brown to black, S = red-brown**	metallic, earthy
Limonite	common iron mineral	impure iron oxide	**yellow-brown to dark brown**	earthy
Magnetite	iron ore	iron oxide	**black**, S = black	metallic
Malachite	weathering product	hydrated copper carbonate	**green**	earthy
Mica Group	rock-forming silicates	complex silicates	muscovite = white, chlorite = green, biotite = black	glassy
Molybdenite	molybdenum ore	molybdenum sulphide	**lead-grey with bluish trace,** S = grey	metallic
Olivine	rock-forming silicate	complex iron-magnesium mineral	**olive green, olive brown**	glassy
Pyrite	common iron mineral	iron sulphide	**pale yellow, S = black**	metallic
Pyrrhotite	common iron mineral	iron sulphide	**bronze-yellow**, S = black	metallic
Quartz	rock-forming mineral	silicon oxide	clear, white and varied colours	glassy
Silver	metal	impure silver	**silver-white**	metallic
Sphalerite	zinc ore	zinc sulphide	yellow-brown to black, **S = yellow brown**	resinous to poor metallic
Tetrahedrite	sulphide	copper-antimony sulphide	**grey to iron-black,** S = grey to grey-black	metallic

COMMON AND IMPORTANT MINERALS

Form	Cleavage	H	D	Other
crystals, needles, massive	none	**5.5**	6	garlic odour when struck
earthy or **tiny crystals**	seldom visible	2-3	3.5	**often found with malachite**
tabular crystals, massive	2 good	3	**4.5**	
massive	none	3	5	**iridescent purple tarnish**
crystals, grains, massive	**3 at 60°**	3 3.5 4	2.7	**calcite-fizzes with acid; dolomite and siderite fizz slowly when powdered; siderite is brown**
massive, grains	none	**3.5**	4	"fool's gold"
massive, grains	none	**5.5**	4	
granular, massive, as stains	none usually visible	**2.5**	8	
stubby crystals (augite), long crystals (hornblende)	**good-two directions**	**5.5**	3	
grains, crystals, massive	**2 at 90°**	**6**	2.7	often impossible to distinguish without tests
cubes or massive	**3 perfect at 90°**	2.5	**7.5**	
12 or 24-sided crystals, massive	**none**	7	3.5	
irregular small grains	**sectile**	**2.5-3**	12-19	
massive or earthy	1 good, 1 poor	**2**	2.5	cleavage best seen on larger crystals
scales, massive or earthy	none-may break in flakes	**5-6**	5	often has magnetic impurities
massive, often powdery	none	3-5	3.5	
usually granular	none	5-6	5	**strongly magnetic**
earthy or tiny crystals	seldom visible	2-3	3.5	**often found with azurite**
in flakes	**1 perfect**	**2.5**	3	muscovite flakes are clear; chlorite flakes bend easily; biotite flakes dark
flakes, scales, massive	1 good	**1.5**	4.5	
grains, rarely massive	**none**	**7**	3.5	
cubes, grains, massive	none	**6**	5	"fool's gold"
massive	none	4	4.5	**moderately magnetic**
6-sided crystals, grains, massive	**none**	**7**	2.7	glassy fracture
irregular small masses	**sectile**	**3**	10	black tarnish
crystals, grains, cleavable masses	**several directions**	**3.5**	4	
small crystals, grains, massive	none	**3.5**	4.5	brittle

CHAPTER 3 — IDENTIFICATION OF ROCKS

INTRODUCTION

Rocks are exposed on the earth's surface or buried at varying depths under soils, sands, gravel, or other debris. The earth's crust down to a depth of many kilometres is composed of rock types which will be dealt with in this chapter and Chapter 4.

An exposure of rock at the earth's surface is called an **outcrop**. A useful general term for any material covering or obscuring rocks from view is **overburden**.

Rocks are important to prospectors for a variety of reasons, the chief of which are:

(1) They host mineral deposits.
(2) Certain mineral deposits are associated with particular types of rock.
(3) A knowledge of rocks is essential to understanding published maps or to making your own geological maps.

Most definitions of a rock describe it as a hard, naturally formed mixture of mineral matter. All rocks are composed of varying proportions of different minerals. In some rarer rocks, there may be only one mineral present, but usually there are from two to six. Although most rocks are made up from only about a dozen or so very common rock-forming minerals, there is in fact a great variety of different rock types. This is because minerals may be present in a variety of grain sizes, textures, and proportions and because rocks are formed through a variety of natural processes.

Fortunately only a few of the very many rock types are really common, and we can use comparatively simple **field names** for rocks in our classification schemes. These field names do not require advanced knowledge nor laboratory tests.

The important point in identifying a rock in the field is to be consistent. If you can consistently recognize a rock in the field every time you see it, this is more valuable to you than the name you call it; it is not important that some expert might have a different or fancier name for it than the one you are using.

The most common minerals found in rocks are quartz and what are called the "rock-forming silicate minerals". These include olivine, the dark minerals — augite and hornblende, the micas — biotite and muscovite, and the feldspar group. Other silicate minerals such as the clay minerals, chlorite, and garnet are important in some kinds of rock. Following the silicates in importance are the carbonate group minerals, the various iron oxides, and sulphates such as gypsum.

CLASSIFICATION

The first task in rock identification is to decide to which of the three major families of rocks it belongs. These are the **igneous rocks**, the **sedimentary rocks**, and the **metamorphic rocks**.

IGNEOUS ROCKS

An igneous rock is formed by the cooling of molten silicate material which we call **magma** if it is confined below the earth's surface or **lava** if it escapes to the earth's surface or pours out onto the sea floor. Because they are also derived from the cooling of molten silicate material, rocks that form from volcanic ashes or other material blown out of a volcano are usually considered to be igneous, even though they may have characteristics of the sedimentary family.

Igneous rocks tend to form large masses, often occupying several cubic kilometres, but they also occur as tabular bodies within other rocks or as irregular lava flows. Igneous rocks almost always are composed of crystals but rarely they may be composed of natural glass. Because they are composed of silicate minerals and since most rock-forming silicates are hard, igneous rocks tend to be difficult to scratch.

The size of crystals in igneous rocks is largely a result of the time available for cooling from the molten to the solid state. The larger the crystals, the longer the cooling period (often in the millions of years). Lava flows tend to cool rapidly, and thus have tiny crystals, or rarely, no crystals at all. Larger crystals, which may be scattered through some lavas, were formed before the lava was erupted. You should be able to see that at least some of the crystals in igneous rocks have sharp edges or corners.

SEDIMENTARY ROCKS

A sedimentary rock is formed from cemented or compacted **sediments** which are composed of the debris resulting from the weathering and breakup of other rocks, that have been deposited by or carried to the oceans by rivers, or left over from glacial erosion, or sometimes from wind action.

Since most sediments are carried by rivers to the sea, sediments are deposited in layers, one upon the other. This layering is preserved in the sedimentary rocks and is called **stratification** or more commonly **bedding**. Bedding is the most important feature of sedimentary rocks. Beds are usually close to horizontal when formed, but they may become tilted, folded, or distorted by later earth processes (Fig. 3-1).

If you can see the sediment particles you will usually see signs of wear or rounding, and see that the particles are cemented together.

Some sedimentary rocks are formed from chemical precipitates that are formed when dissolved materials deposit or inland seas evaporate. Other sedimentary rocks are formed when living organisms turn dissolved materials into shells which accumulate when the organisms die. Many sedimentary rocks contain fossils. They vary in abundance from very rare to 100 per cent of the rock (Fig. 3-2).

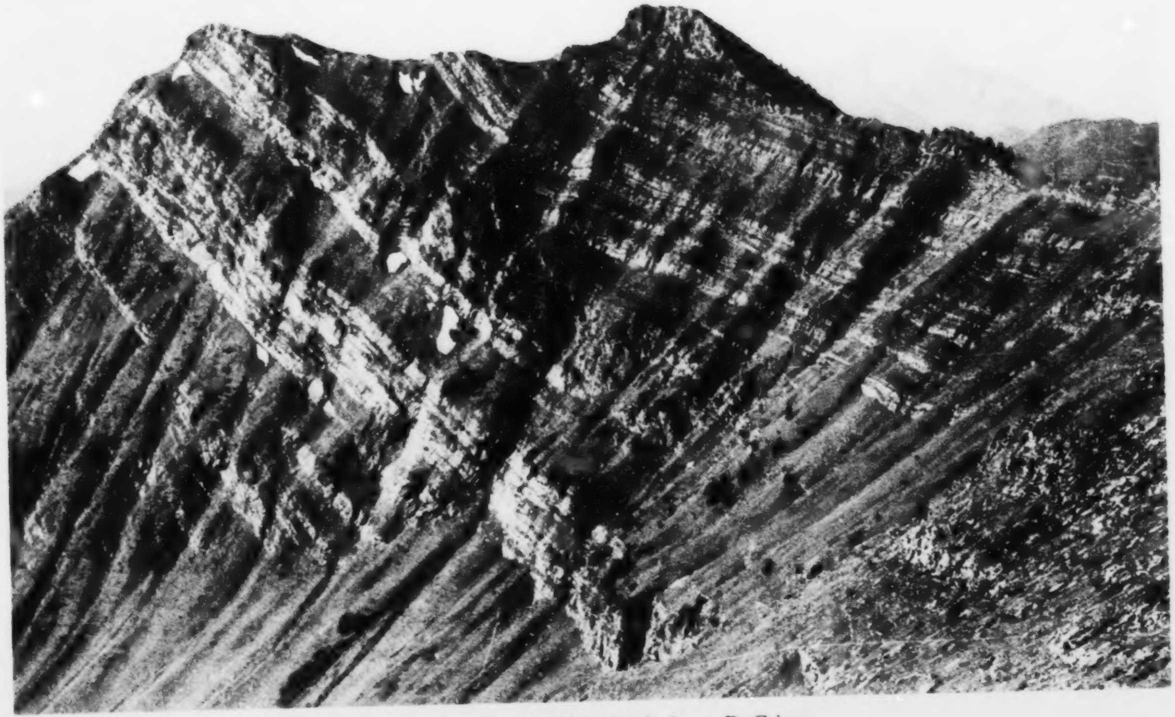


Figure 3-1. Tilted sedimentary beds. — D. Grieve

METAMORPHIC ROCKS

Whenever any rock is altered deep within the earth's crust by the effects of heat, pressure, or chemical reactions, the altered rock is called a metamorphic rock. Sometimes the alteration is only slight and we have no difficulty in seeing what the original rock was. Sometimes the original rock may be altered beyond recognition. Too much heat may cause the rock to melt and then we have a magma.

Generally, the effects of metamorphism are to **recrystallize** the original materials into a dense mass or to cause **new minerals** to form or to impart distinct mineral layering called **foliation** to the rock. Foliation may result from the formation of new minerals during metamorphism or the recrystallization of old minerals.

New minerals which commonly form during metamorphism include biotite, muscovite, chlorite, and garnet. Biotite and muscovite may have been present in the unaltered rock also, but chlorite and garnet are usually abundant only in metamorphic rocks. For simplicity, several other minerals which occur less commonly in metamorphic rocks have been omitted from the mineral tables, so do not be surprised if you occasionally come across metamorphic rocks containing minerals that you cannot identify.

Metamorphic rocks are generally the most difficult to deal with in the field. Foliation may be mistaken for the bedding of sedimentary rocks for example, or recrystallized minerals may be mistaken for those in an igneous rock.

PRACTICAL TIPS

(1) Do not feel that after reading this book or completing a course in prospecting you should be able to identify every rock you come across in the field, or even to be sure to which of the three families it belongs. Remember to be consistent — even if it turns out that you are wrong! You can always change a field name or ask a geologist what he would call your "Rock X". Professional geologists are sometimes surprised by what some rocks turn out to be when results of laboratory tests are completed — more so than many of us will admit!

(2) Outcrops are likely to be weathered to some extent, and you will need to use your geological hammer to get fresh samples to look at. However, do not get so used to using your hammer that you neglect to look at the weathered surface as well. While weathering usually makes it difficult to identify rocks, sometimes the opposite is true. Structures like bedding or foliation, for example, are often clearer on weathered surfaces. Some minerals have distinctive shapes or colours which show up best on weathered surfaces also.

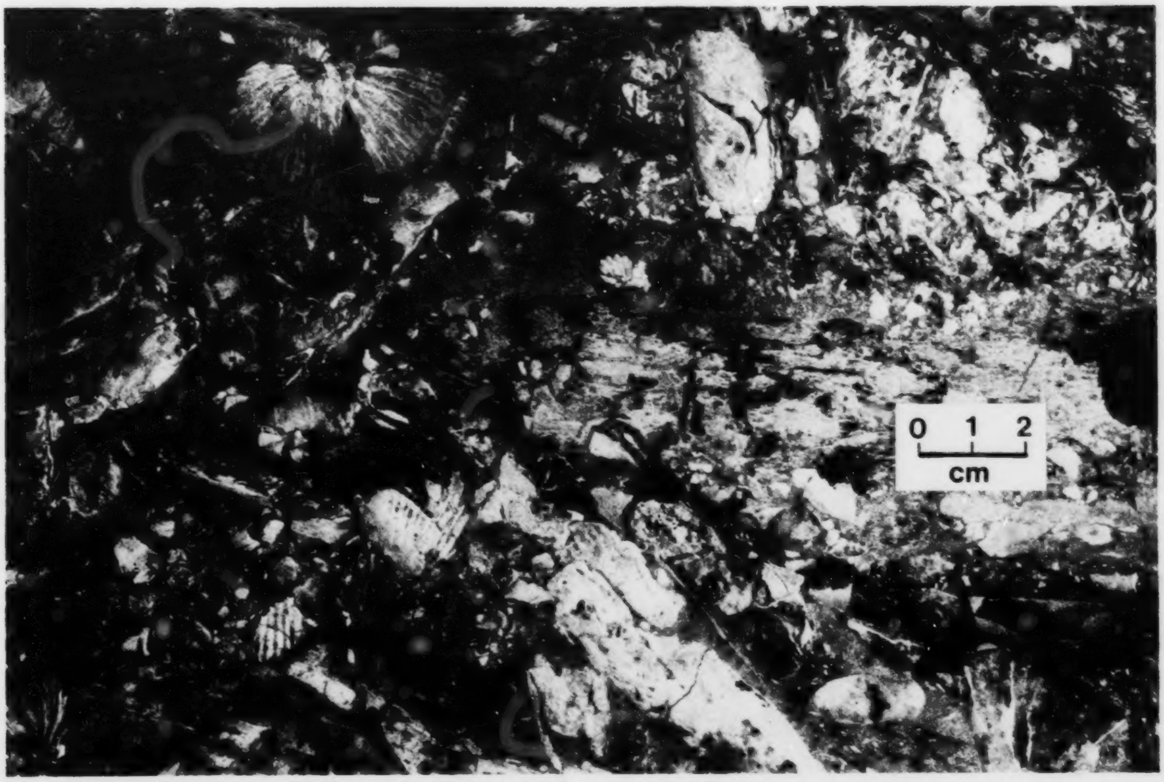


Figure 3-2. Fossiliferous limestone.

(3) The number of names and terms you will meet in this book may well be confusing at first, but try to use the terms "rock" and "mineral" correctly, and not use rock names for minerals and vice versa. A geologist will not expect you to have professional knowledge, but he or she will quickly realize whether you know what you are talking about. The correct use of "rock" and "mineral" will get you off to a good start. Minerals are the ingredients of which rocks are composed. To change the situation, imagine trying to convince someone you know a little about baking if you do not know the difference between "flour" and "bread".

THE IDENTIFICATION OF IGNEOUS ROCKS

The best way to classify igneous rocks is first to separate those formed from ashes or other material blown out of a volcano and deal with them separately. This type of rock is called a **pyroclastic rock** and consists of a highly variable mixture of rock fragments, cinders and ashes, and bits of crystals and glass. A finer grained pyroclastic rock made up mostly of ashes is called a **tuff**; it may show quite good bedding, since ashes fall from the air and are deposited in layers just like other sediments. Coarser grained pyroclastic rocks made up mostly of cinders and rock fragments for simplicity can be called by the family name **agglomerate**.

The balance of the igneous rock types can be "pigeonholed" by means of two key features (Table 3-1):

(1) The **overall crystal size** as follows:
    (a) Coarse.
    (b) Medium or mixed coarse-plus-fine.
    (c) Fine or glassy.

(2) The **overall colour impression of the rock** as follows:
    (a) Light.
    (b) Medium.
    (c) Dark.
    (d) Very dark or greenish.

The reason for this approach is that the crystal size tells us something about the cooling history of the rock while the colour reflects the mineral composition — that is the proportion of light minerals to dark minerals. Using this scheme then, you have only to ask: (1) the overall crystal size and (2) the overall colour impression, then you have a field name for the rock.

Try this scheme and see how you do. Following Table 3-1 there are some Additional Notes giving further details, which may help clear up any difficulties. However, you will probably find you can do reasonably well without consulting these notes.

TABLE 3-1. IDENTIFICATION OF IGNEOUS ROCKS

Key Questions:

1. What is the overall crystal size?
2. What is the overall colour impression?

Question 2. (Overall Colour) ⟶

Question 1. Crystal Size	LIGHT 2/3 or more light minerals	⟵ MEDIUM 1/2 & 1/2 ——	DARK 2/3 or more dark minerals ⟶	VERY DARK or GREENISH mostly dark minerals or olivine
↓ COARSE ↑	**GRANITE**	**DIORITE**	**GABBRO**	**ULTRAMAFICS**
MEDIUM or MIXED	**DIABASE** ⟵ **PORPHYRIES** ⟶			
↓ FINE (or GLASSY)	**RHYOLITE**	**ANDESITE**	**BASALT**	**OLIVINE BASALT**

ADDITIONAL NOTES

The terms "coarse", "medium", and "fine" are used relatively, but in geological usage "coarse" is 5 millimetres (about 0.2 inch) or larger and "fine" is 1 millimetre (about 0.04 inch) or smaller.

The colour terms are used relatively too, but "light" should mean more than half the rock consists of light minerals (quartz, muscovite, feldspars), "dark" means more than half the rock consists of dark minerals (olivine, augite, hornblende, biotite), and "very dark or greenish" means almost all the rock is composed of dark minerals or olivine.

Most of the "pigeon-holes" in this classification scheme actually group together a family of similar rock types. With purchased sets of rocks and most rocks used in prospecting courses you will probably have little difficulty placing the specimens in their proper pigeon-holes if you use this scheme. In the field, however, you will often find rocks that seem to be halfway between two pigeon-holes. In such cases, make a decision or "value judgment" about which of the two possibilities you are going to use. As has been stated before, once you have made a choice, be consistent.

Notes on Individual Igneous Rocks

Granite — Granites are normally pale pink, pale pink-brown, or pale grey. They should have lots of easily visible quartz. There is usually more potash feldspar than plagioclase (Fig. 3-3).

Diorite — The old prospector's term for diorite is "salt and pepper rock". It should have half dark and half light minerals and little or no quartz (Fig. 3-4).

Gabbro — Gabbros are usually dark grey to very dark grey and should have no quartz. The feldspar should be plagioclase (Fig. 3-5).

Ultramafics — Ultramafic rocks are less common than other igneous rocks. A **peridotite** contains abundant olivine and some augite, and looks dark green, while a **dunite** is made up almost entirely of olivine and looks green or dark green. In British Columbia, ultramafic rocks are often partly or completely altered to metamorphic rocks called **serpentinites**; typically they are very soft, dark green to almost black, and break into slabs or lenses with smoothly polished faces.

Diabase — Note this is the only medium-grained rock on the table and, apart from the grain size, diabases look much like gabbros. You must make a value judgment for any other medium-grained rocks you find and name them as if they were coarse or fine grained.

Porphyry — This is a common rock type with mixed crystal sizes. Note it does not matter what the overall colour is. The big crystals in a porphyry are called **phenocrysts** and

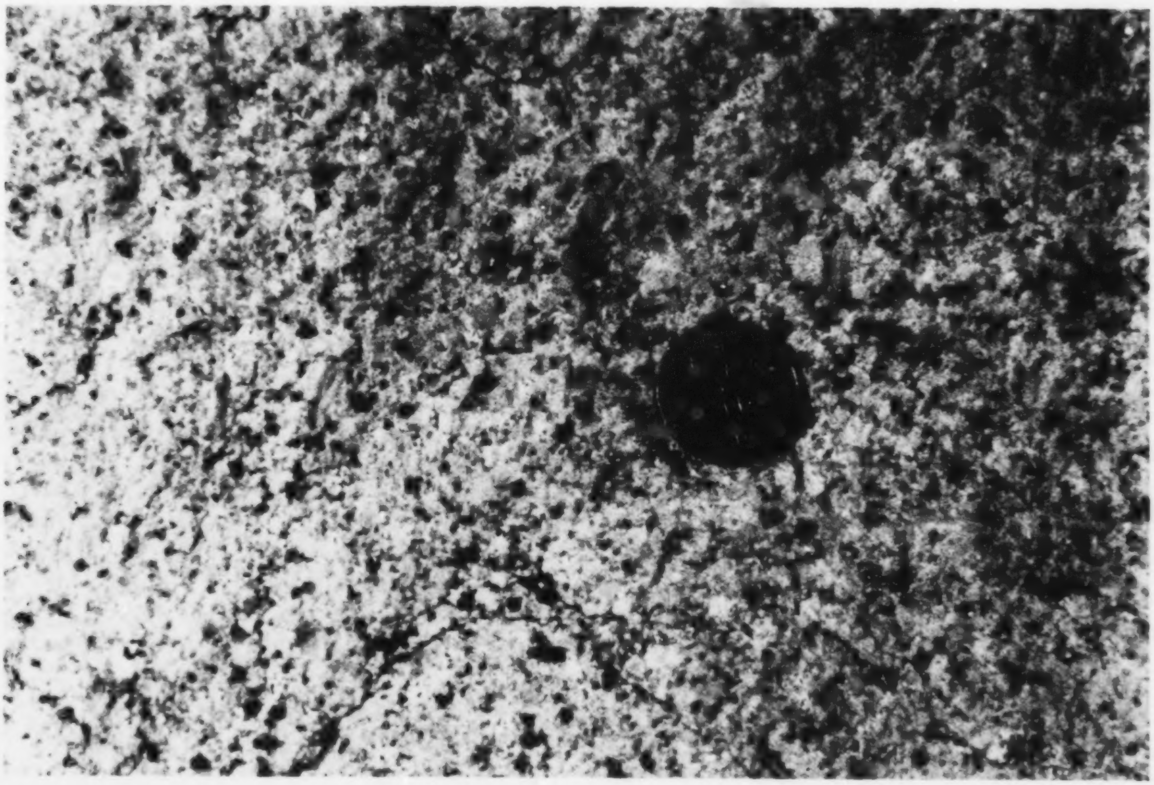


Figure 3-3. Granite.

the fine-grained material is called the **groundmass**. If you can identify the phenocrysts, you can put the mineral name(s) in front of the word porphyry, for example, "hornblende porphyry", "quartz-feldspar porphyry", and so on (Fig. 3-6).

Rhyolite — You may see the word **felsite** used in this pigeon-hole. Felsite is actually a more correct, but less commonly used, term to describe this family. Most rhyolites are either light grey or light brown in colour and, like all the fine-grained igneous rocks, may show evidence of their origin as a lava flow, such as gas bubbles, called **vesicles**, and **flow banding** — streaks in the lava created by movement.

Andesite — Andesites are usually a medium grey in colour, but some are red-grey or purplish grey.

Basalts — Almost all basalts are very dark grey, rarely they may be very dark brownish grey or greenish grey.

OTHER IGNEOUS ROCKS

You are most likely to come across the names of other igneous rock types on geological maps or in geological reports. Following are some of these rock types. A few of them can be identified in the field, and you may wish to add them to your classification scheme; others require laboratory study to identify them.

Syenite — Most syenites are pale brown or pinkish brown and look like granites but without the quartz. They usually contain 70 to 80 per cent of feldspar, mostly orthoclase, and very little or no quartz. They are much less common than granite. The fine-grained or volcanic equivalent of a syenite is a **trachyte** which is usually indistinguishable from a rhyolite in the field.

Pegmatite — A pegmatite is a very coarse-grained igneous rock. Almost all the minerals are present as very large crystals, at least 2 centimetres in size. Pegmatites are named after the rock type they would be if the crystals were normal in size, for example, granite pegmatite, diorite pegmatite.

Granodiorite and ***Quartz Diorite*** — These very similar rock types are members of the diorite family. "Granodiorite" or "quartz diorite" is often used as a field name for an igneous rock that is intermediate in composition between granite and diorite. The fine-grained or volcanic equivalent of these rocks is **dacite**. Dacites usually look like rhyolites.

Monzonite and ***Quartz Monzonite*** — These are fairly common members of the granite family, but since they are defined as having certain proportions of quartz, orthoclase, and plagioclase, they can seldom be identified in the field. Their fine-grained or volcanic equivalents are **latite** and **quartz latite** respectively; they look like rhyolites.

Volcanic Breccia — This is an agglomerate with angular (sharp-edged) volcanic rock fragments. Volcanic breccias are generally the result of explosive volcanic activity, but they may be caused by landslides cascading down the slopes of a volcano (Fig. 3-7).

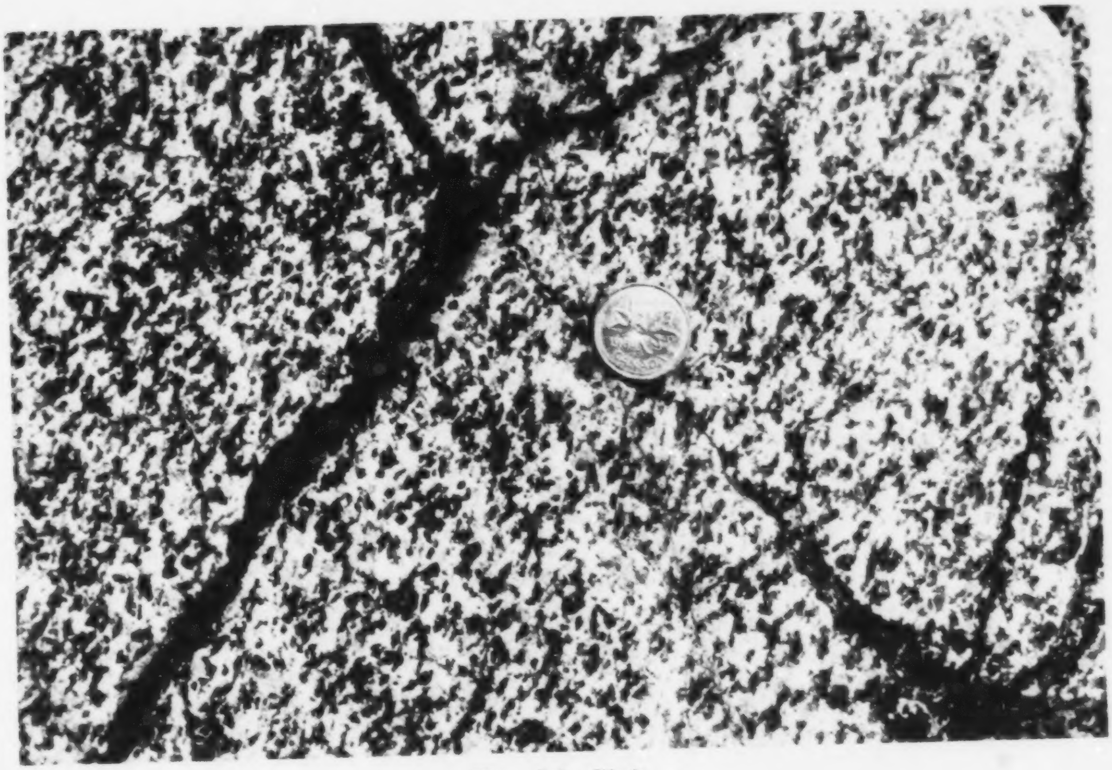


Figure 3-4. Diorite.

Figure 3-5. Gabbro.

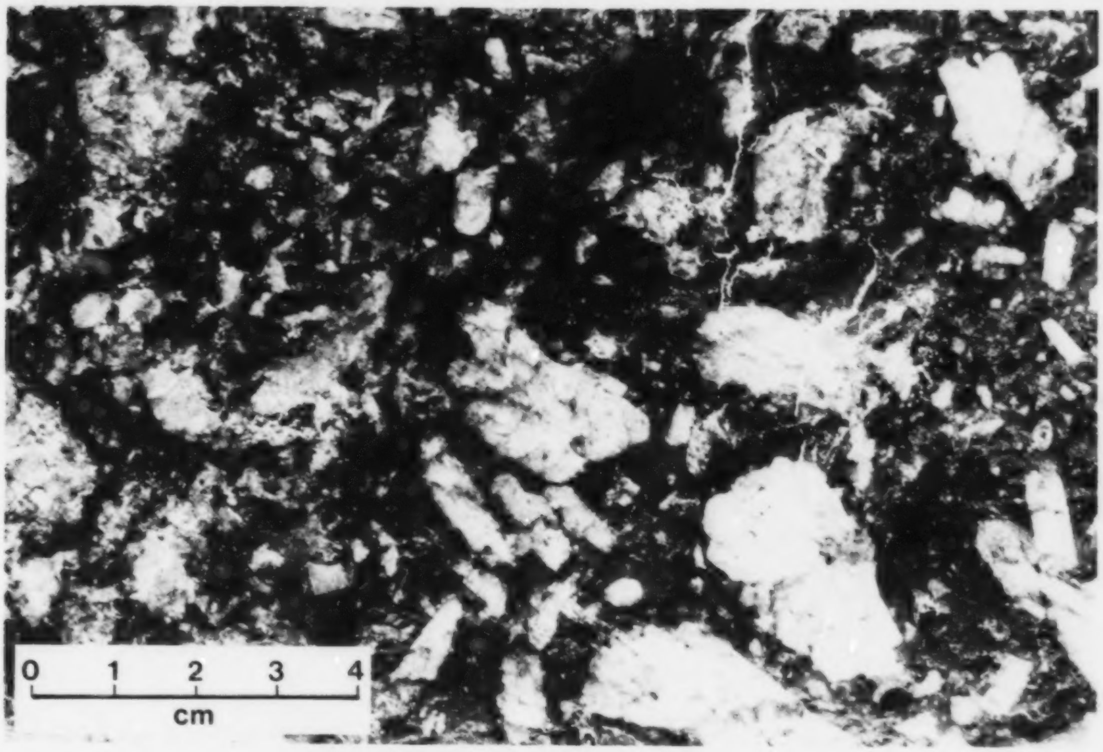


Figure 3-6. Feldspar porphyry.

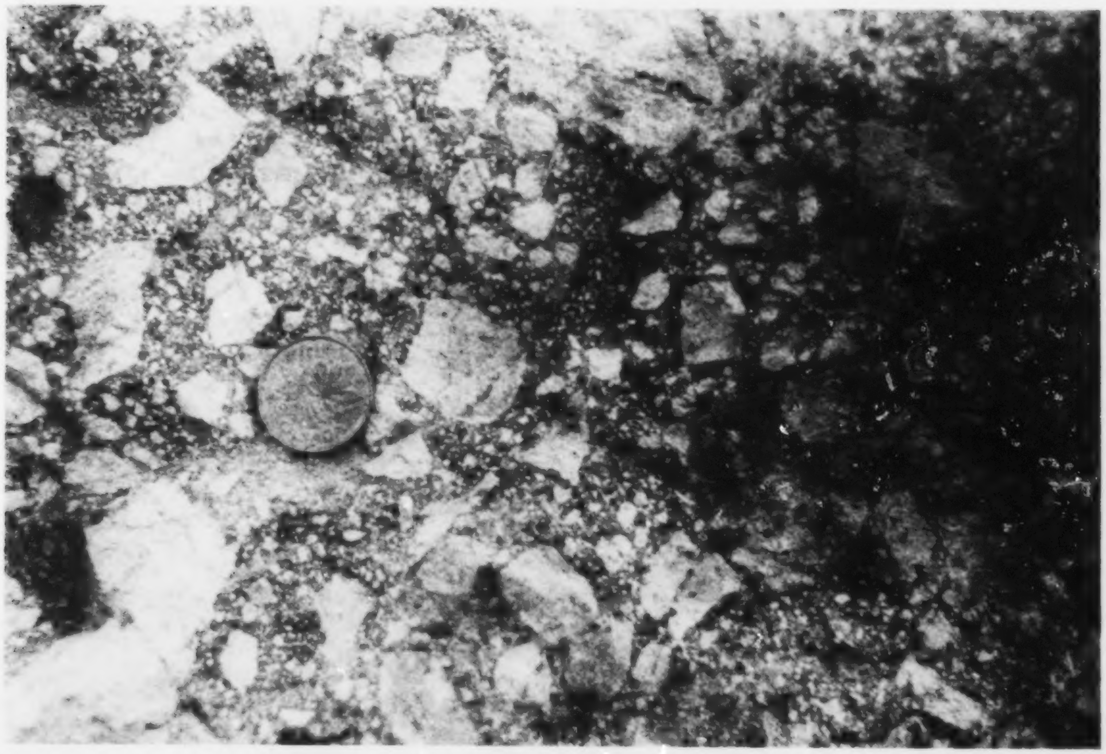


Figure 3-7. Volcanic breccia.

CHAPTER 4 — IDENTIFICATION OF SEDIMENTARY AND METAMORPHIC ROCKS

SEDIMENTARY ROCKS

The general characteristics of sedimentary rocks have already been described. A useful and relatively simple scheme (Table 4-1) for classifying them is based on their mode of origin — whether they are (1) of chemical or organic origin or (2) of mechanical origin.

CHEMICAL OR ORGANIC ORIGIN

Rocks of chemical origin originally result from some kind of chemical reaction or process in the shallow waters near the coastlines or some kind of chemical reaction which takes place when sediments are buried. Rocks of organic origin consist mostly of calcite from shells or shell fragments or calcite secreted by certain animal and plant organisms, as in coral reefs.

Limestone — Limestone is composed mostly of the mineral calcite, therefore all limestones should fizz readily with acid and, if they are reasonably pure, they can be scratched easily with a knife. The calcite may be of either chemical or organic origin and, if organic, fossils may be preserved. Some fossils are distinctive and enable experts to tell the geological age of the rock.

Limestones are commonly grey, white, or off-white, and less commonly brownish, red, or black. The grain size varies greatly, but most limestones will have tiny patches of visible calcite or veinlets of calcite or calcite-filled shells. Limestones in the field are massive to well bedded and, in our northern climate, often weather into rough outcrop surfaces, with small to fist-sized hollows and cavities in them.

Dolomite — This is one of the rare cases where the name of the rock is the same as the name of the main mineral in the rock. Dolomites are generally similar to limestones and may not be distinguishable from them without an acid test. Dolomites do not fizz much with acid, but you will get a slight reaction if you test a fresh scratch or some finely powdered rock.

Dolomites are chemically altered limestones. Usually they are coarser, and fossils are rarely well preserved. The rocks tend to weather to form rather rough surfaces that are often buff coloured. Dolomites are usually more massive or thicker bedded than limestones.

Chert — Cherts are very fine-grained or glassy rocks. They have the same composition as quartz but usually with water and other impurities present. Most are chemically formed but not recrystallized and, as a result, are dull and greasy looking. They are very hard and highly variable in colour. Some areas may have relatively large quantities of chert in the form of nodules (irregular rounded lumps), lenses, or beds.

MECHANICAL ORIGIN

This group of sedimentary rocks is composed of fragments of other rocks that were broken down during weathering and erosion processes; they have usually been carried to the sea by streams and rivers. As they become deeply buried, water is squeezed out and they become cemented together into solid rock. This group usually shows excellent bedding in the field. The simplest way to classify them is on the basis of the size and sometimes the shape of the fragments.

Sedimentary Breccia — The term "breccia" describes a rock composed of mostly angular fragments. Breccias can in fact form in different ways, but a sedimentary breccia should be composed of fragments of gravel size or larger. The majority of these fragments must be angular. Bedding in breccias is usually rather coarse and may be lacking. Sedimentary or metamorphic rock fragments or both are common, which helps distinguish them from volcanic breccias.

Conglomerate — A conglomerate is also composed of fragments which are of gravel size or larger. The majority of these fragments must be rounded. Bedding in conglomerates is also usually rather coarse.

Grit — Grit is a useful field term for a rock with fragment sizes between those of a conglomerate or breccia and a sandstone, described following. The grain or fragment size is very fine gravel or very coarse sand.

Sandstone — A sandstone is composed of sand-sized fragments cemented together. As a rule the fragments contain a high percentage of quartz; most sandstones will scratch your penknife and you should be able to see the rounded grains with your magnifying glass. Impurities may give a wide variety of colours; greys and browns are the most common. Sandstones sometimes contain fossils and they are often well bedded.

Shale — A shale consists of silt or clay-sized particles cemented together. Individual fragments are rarely visible, even with a powerful magnifying glass. Bedding is usually very well developed; you can often split shales along the bedding with ease. Some shales may contain excellent fossils. Most shales are quite soft, because they contain large amounts of clay minerals. They therefore scratch and erode easily. In British Columbia and other parts of Canada that have been heavily glaciated, shales are likely to be exposed in outcrops only in more rugged country or where protected from ice erosion.

METAMORPHIC ROCKS

As mentioned before, the effects of metamorphism are either to recrystallize the original minerals into a dense crystalline mass or to cause a distinct mineral layering called

TABLE 4-1. IDENTIFICATION OF SEDIMENTARY ROCKS

Key Question: Is it composed of particles cemented together — particles nearly always showing signs of wear?

1. If so, then identify on basis of **Size of Particles.**

	Particle Size	Rock
LARGE	Gravel size or larger and mostly **Angular**	**Breccia**
↑	Gravel size or larger and mostly **Rounded**	**Conglomerate**
↕	Fine gravel to coarse sand	**Grit**
↓	Sand-sized	**Sandstone**
MICROSCOPIC	Clay or mud-sized fragments — not visible, but rock is soft and does not fizz with acid	**Shale**

2. If not, then identify on basis of **Composition.**

Composition	Rock
Composed of **Calcite.** (scratches easily, fizzes readily with acid)	**Limestone**
Composed of **Dolomite.** (scratches easily, may not fizz much with acid, but some fizzing on fresh scratch or powdered rock)	**Dolomite**
Composed of **Silica.** (non-crystalline, very hard and dull, glassy looking)	**Chert**

foliation in the rock. Our classification scheme (Table 4-2) follows this division.

MASSIVE OR RECRYSTALLIZED ROCKS

This group is usually classified on the basis of composition. They may vary from very fine grained to very coarse grained.

Marble — A marble is a recrystallized limestone. It is usually fairly coarse and consists of interlocking calcite crystals, best seen on a freshly broken surface. It fizzes readily with acid and is easily scratched with a penknife. Any bedding in the original limestone is usually destroyed, but traces may be visible as pale or dark colour bands.

Quartzite — A quartzite is a recrystallized sandstone with intergrown, interlocking quartz grains; it is difficult to tell a quartzite from some sandstones. Quartzites are very hard, they are usually massive and should be free of rounded sand grains. They may have pale colour bands marking the remains of bedding.

Greenstone — A greenstone is an altered basalt or andesite. It is a very common rock type in the interior of British Columbia and elsewhere where there has been a long history of volcanic activity. Greenstones are almost always greenish or greenish grey, due to a high content of chlorite and other greenish minerals. They are variable in both colour and texture, are usually massive, and often form sizeable outcrops. Some greenstones may have a poorly developed foliation.

Hornfels — A hornfels is formed when certain rocks are exposed to the intense heat and chemical fluids given out by a nearby igneous intrusion; in fact they are sometimes called **contact metamorphic rocks**. If formed from fine-grained rocks, such as shales or some volcanic rocks, hornfels are fine grained and difficult to identify on sight. They are usually grey and very hard; they may be slightly to moderately magnetic. If formed from coarse-grained rocks or from limestones and dolomites, hornfels usually consist of a hard mass of silicate minerals, often with iron oxides (magnetite or hematite) and sometimes iron sulphides (pyrite or pyrrhotite).

A coarse-grained hornfels composed of garnet, plus other silicate minerals, and sometimes calcite is called a **skarn**.

FOLIATED ROCKS

These rocks are easily classified by the coarseness of the foliation and by how easily the rock breaks or "cleaves" along the foliation. The development of foliation starts at the microscopic level, with crystals growing in layers. As metamorphism progresses, these crystals grow until they become visible, then they begin to segregate into distinct layers.

Slate — A slate is very fine grained with no visible crystals or mineral flakes, although it may have a few larger crystals,

TABLE 4-2. IDENTIFICATION OF METAMORPHIC ROCKS

Key Question: Is it foliated in any way?

1. If so, then identify on basis of **Type of Foliation.**

	Type of Foliation	**Rock**
COARSE	Mineral layering or segretation, rock may break irregularly	**Gneiss**
↑ MEDIUM ↓	Minerals visible and sometimes identifiable, but not segregated. Rock breaks readily along the foliation, broken surfaces rough	**Schist**
FINE or MICROSCOPIC	Minerals too fine to see, rock breaks easily along foliation, broken surfaces fairly smooth	**Slate**

2. If not, then identify on basis of **Composition.**

Composition	**Rock**
Composed of **Calcite** usually in the form of uniform sized interlocking crystals. (scratches easily, fizzes readily with acid)	**Marble**
Composed of **Quartz.** (very hard, little or no bedding visible)	**Quartzite**
Composed of fine-grained **greenish silicate minerals.** Minerals may sometimes be identified. Rocks usually massive with much variation in texture — altered lava flows.	**Greenstone**
Very dense rock composed of **silicates, iron oxides** and **sometimes sulphides.** (rocks usually magnetic and may be fine to coarse-grained)	**Hornfels**

often pyrite, scattered throughout. Slates have excellent foliation called **slaty cleavage**, and readily break into slabs or sheets with smooth surfaces; these cleavage surfaces are often at an angle to the original bedding, which may show up as faint colour bands (Fig. 4-1).

Schist — Crystals or mineral flakes are visible but not necessarily identifiable in a schist. They have good foliation, called **schistosity**, and they break into slabs which are thicker and much less smooth than those of a slate.

Gneiss — In a gneiss the crystals and flakes are readily visible, and minerals such as quartz, biotite, or muscovite can usually be identified. The minerals are at least partly segregated into layers, lenses, or rod-like masses. Usually all the light-coloured minerals will segregate together as will all the dark minerals. As a result the foliation is rather coarse, and a gneiss may or may not break along the foliation (Fig. 4-2).

If there is a large amount of some mineral in a schist or a gneiss, then the name of that mineral can be placed in front of the rock name, for example, chlorite schist, hornblende gneiss.

COMMENTS ON ROCK IDENTIFICATION

To start with, you may wish to write out the classification schemes for the three rock families on a series of cards, to help the memory process. Getting an unknown rock into the right family — igneous, sedimentary, or metamorphic — is half the battle. It will help if you can learn what minerals you might expect to find in the different rock families. Table 4-3 gives some general information on rock and mineral associations. Making things easier in the field, as opposed to the laboratory, is the fact that you can see the whole outcrop or outcrops and hopefully the relationships of various rocks to each other. You are also urged to check with available geological maps to get some idea of the types of rocks you should expect to see in any area. Making things more difficult in the field is the fact that our classification schemes are very simple and somewhat arbitrary. In nature rocks vary, and are impure, and may not fit exactly into our arbitrary pigeonholes. There is no substitute for practice, but if you are unsure, try to be consistent and always take samples of any rock type you are unsure of — setting your samples side by side will help you to group them consistently.

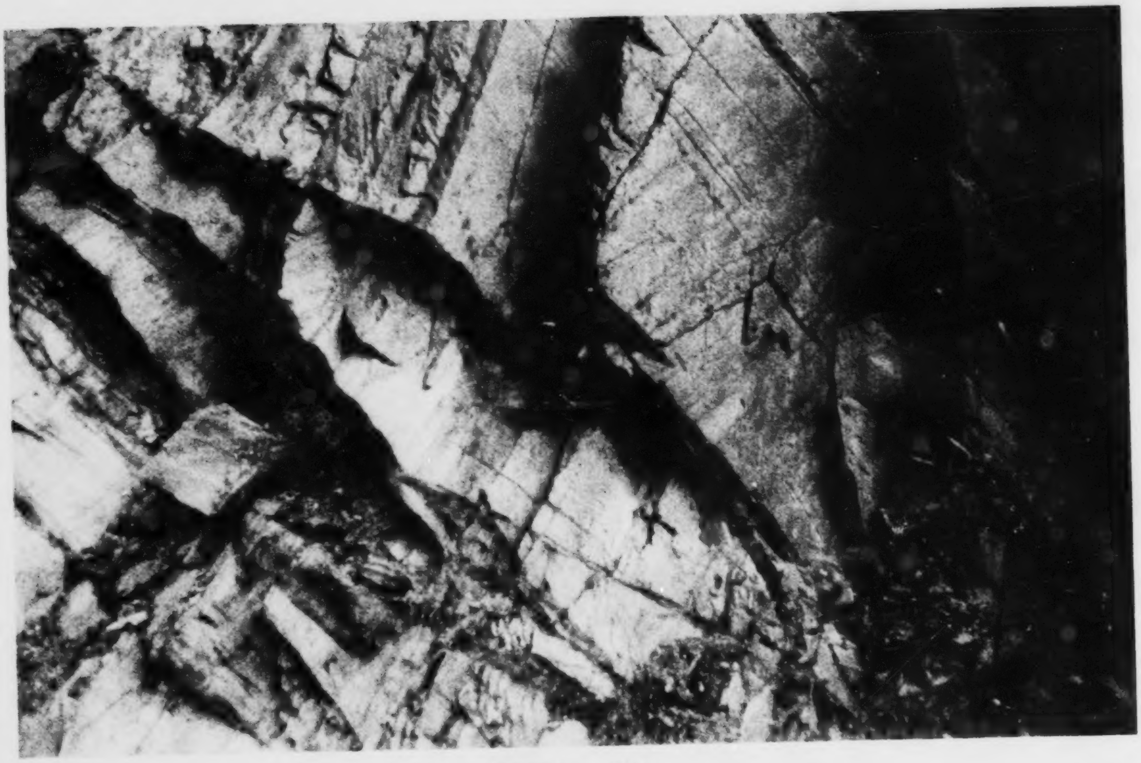


Figure 4-1. Slate.

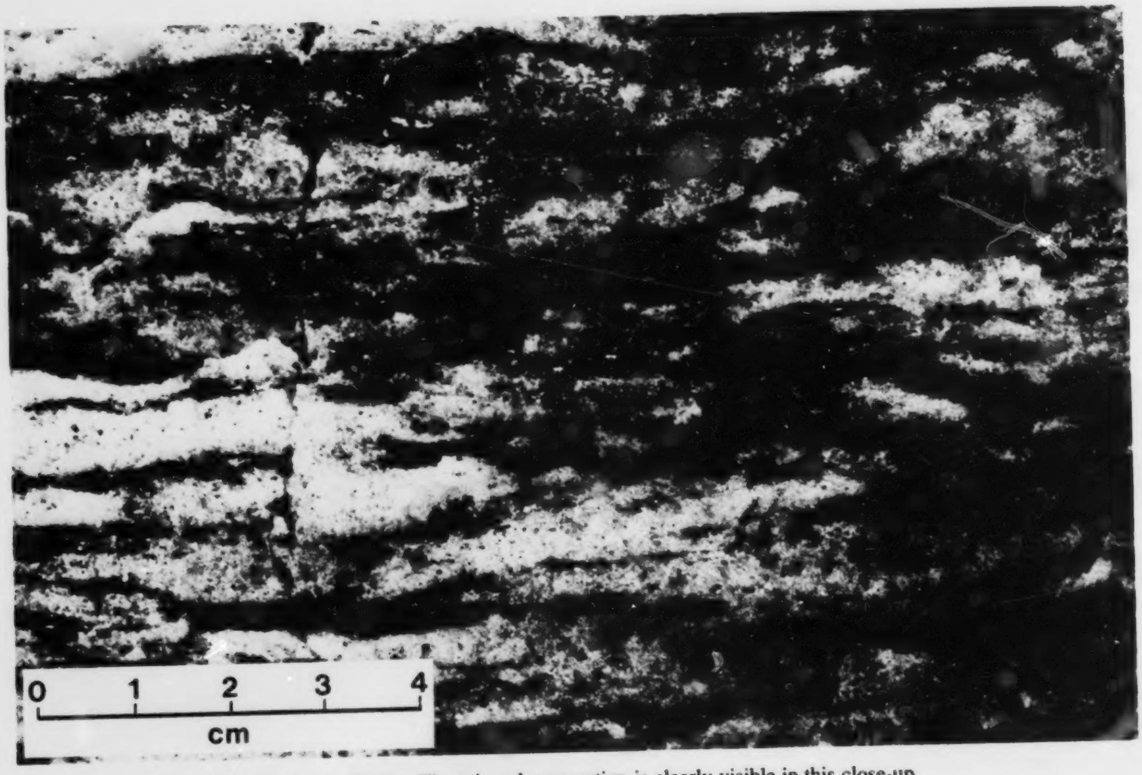


Figure 4-2. Gneiss. The mineral segregation is clearly visible in this close-up.

TABLE 4-3. OCCURRENCE OF THE COMMON AND IMPORTANT MINERALS

Mineral	Igneous Rocks	Sedimentary Rocks	Metamorphic Rocks	Ore Mineral	Gangue Mineral*	Weathered Mineralization
Arsenopyrite				(x)	x	
Azurite						x
Barite		x		(x)	x	
Bornite				x		
Carbonates	(x)	x	x		x	
Chalcopyrite				x		
Chromite				x		
Cinnabar				x		
Dark Minerals	x		x			
Feldspar Group	x	(x)	x			
Galena				x		
Garnet		(x)	x		(x)	
Gold				x		(x)
Gypsum		x				
Hematite		x		x		x
Limonite		x				x
Magnetite	(x)	(x)	(x)	x		
Malachite						x
Mica Group:						
Muscovite	x	(x)	x		(x)	(x)
Biotite	x		x			
Chlorite			x		(x)	
Molybdenite				x		
Olivine	x		x			
Pyrite			(x)		x	
Pyrrhotite					x	
Quartz	x	x	x		x	x
Silver				x		
Sphalerite				x		
Tetrahedrite				(x)	x	

x = common occurrence

(x) = less common occurrence

---

* A gangue mineral is one that occurs with ore minerals, but has no value.

CHAPTER 5 — GEOLOGY

INTRODUCTION

A prospector must know some geology to be successful. We have started with rocks and minerals, but before getting into mineral deposits and the topics that follow, there are other aspects of geology that must be briefly considered. In particular there are a number of terms that you need to know, especially those describing various igneous features and geological structures. This chapter presents an explanation of the more important of these terms.

Unfortunately, little time can be spent going into geological processes — the "how's" and "why's" of rock formation, geological structures and the processes leading to the formation of mineral deposits. Some beginning prospectors may feel that with only a limited knowledge of geology they cannot hope to compete with a geologist who has had years of training. Remember that finding a mineral deposit sooner or later requires looking at the ground, and a prospector with basic knowledge and experience can often do this as well as or better than a geologist. In fact it is not unusual to have prospectors, as well as geologists, on an exploration team. Prospectors have been responsible for the initial discoveries that have led to many of Canada's mines. They are always finding mineralization in areas that have already been "looked at" and sometimes in places where the latest geological theories say it shouldn't be! The discovery of gold at Hemlo, a world class deposit, illustrates this.

Geological knowledge, moreover, is something that can always be added to. If you are near a good city or Community College library, you should be able to find books or articles that are not too technical. Your District Geologist will know what resources are available locally and may be able to give you some suggestions for further reading.

IMPORTANT FEATURES OF IGNEOUS ROCKS

Many mineral deposits are related in some way to igneous rocks, so we will start with several igneous features or structures. These are explained with the aid of Figure 5-1 and the notes which follow. The diagram depicts a slice or vertical section through a volcano and the earth's crust beneath. The rock patterns one actually sees will depend on the state of erosion. Surfaces "A", "B", and "C" which represent increasing periods of erosion, would show quite different features.

Intrusion — This is a general term for a body of igneous rock formed below the surface.

Pluton — This is another term for an igneous intrusion, often used when the size and shape are not known.

Stock — An intrusion which has an exposed surface area of less than 100 square kilometres (40 square miles).

Batholith — An intrusion which has an exposed surface area of more than 100 square kilometres.

Plug or Neck — This is a smaller, roughly circular or oval intrusion formed in the throat or central vent of a volcano.

Dyke — A dyke is a tabular intrusion — this means it is sheet or slab-like. It cuts across or through the host rocks. Dykes vary from a few centimetres to many tens of metres in thickness and may extend for several kilometres (Fig. 5-2).

Sill — A sill is also a tabular intrusion but it is sandwiched between layers in the host rock, such as between sedimentary beds, or sometimes between lava flows. Sills are much less common than dykes.

Roof Pendant — This is a remnant of host rock in the roof of a pluton. It is often surrounded by the intrusion.

IMPORTANT FEATURES OF SEDIMENTARY ROCKS

The most important feature, bedding, has already been described. This is a convenient place to mention the most commonly made measurements in geology — **strike** and **dip**. Figure 5-3 depicts a small outcrop of tilted beds. We can measure the tilt or **dip**, which is the angle between the horizontal and the steepest slope of the beds, with a geologist's compass. We can also measure the direction of the dip with a compass, or alternately the **strike**, which is the direction of a horizontal line on the surface of the bed. Note that the direction of the dip and the direction of the strike are always at 90 degrees to each other. Note too that any planar or flat surface found in the field can be measured by means of the strike and dip or dip and dip direction. Figures 8-5 and 8-6 show a compass being used to measure strike and dip.

IMPORTANT FEATURES OF METAMORPHIC ROCKS

Foliation has been mentioned in Chapter 4. The special terms **slaty cleavage**, **schistosity**, and **gneissosity** are commonly used to describe foliation in slates, schists, and gneisses respectively.

Perhaps the single most important feature of metamorphic rocks as a family is that they can be divided into two kinds, **regional metamorphic** and **contact metamorphic**. Regional metamorphic rocks are found in rather large areas and across a small area such as a few claim units, there may be very little variation in rock type. Slates, schists, and gneisses are typical regional metamorphic rocks. Contact metamorphic rocks, as the name suggests, are typically found at or near the contact of some intrusion. There may be considerable and sometimes sudden changes in rock types, depending on the original host rock and the distance from the intrusion. Hornfels are the typical contact rocks — slates, schists, and gneisses may be absent.

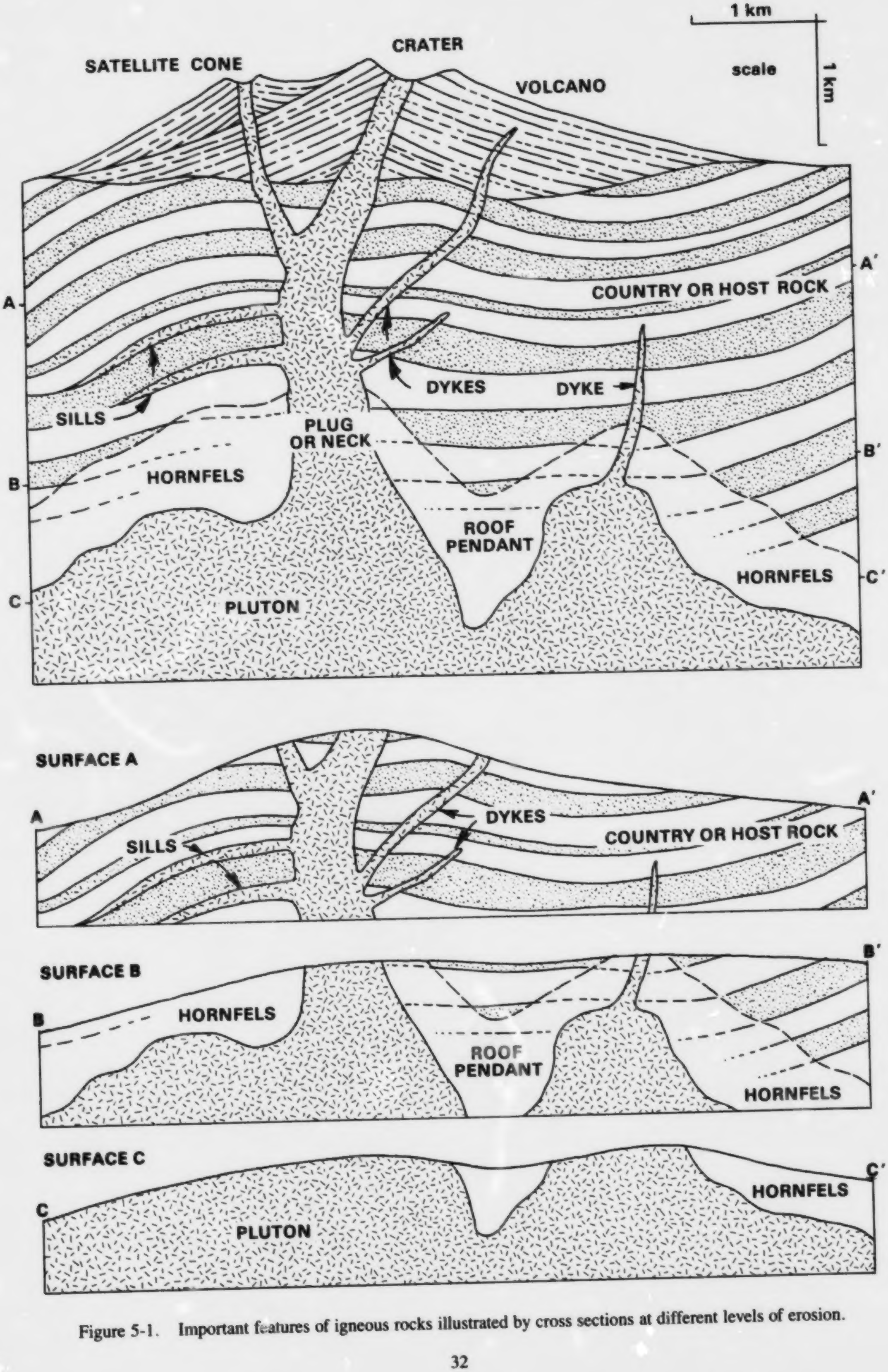


Figure 5-1. Important features of igneous rocks illustrated by cross sections at different levels of erosion.

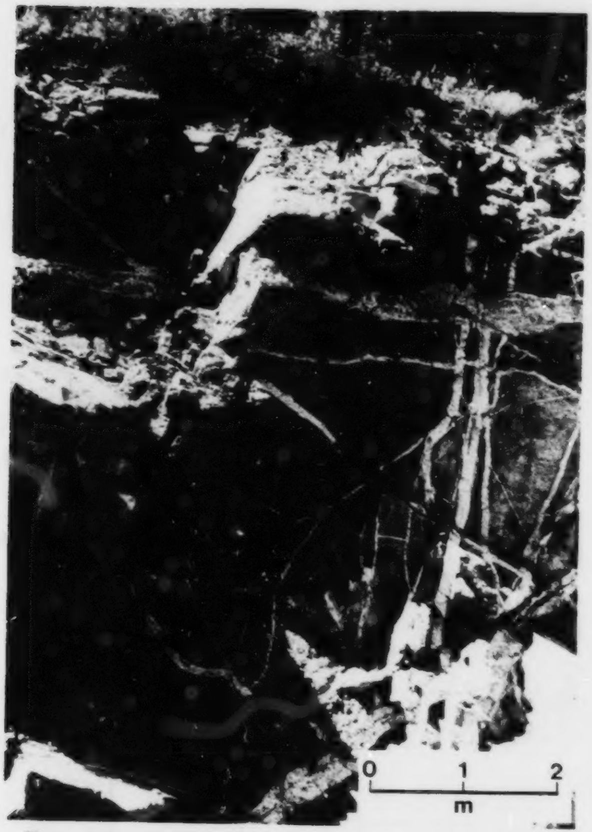


Figure 5-2. A swarm of rhyolite dykes of varying thickness cutting diorite host.

STRUCTURAL GEOLOGY

Structural geology deals with the various structures we find within rocks and mineral deposits, and also with the relationships we find between different rocks in the field. The importance of structural geology to a prospector lies in the fact that all mineral deposits have some kind of structure, and most of them are controlled by the structures existing in their host rocks.

A knowledge of elementary structural geology will help you to understand geological maps and reports. It will also help you to visualize the shape and size of any mineral deposit you find, imagine what it is doing below the surface, and predict where you might look for extensions of the deposit or for other similar deposits.

JOINTS

These are breaks in rocks which show no noticeable movement along them. They often provide porosity and spaces for trapping mineralization. In the mineral deposits known as **porphyry deposits** for example, sulphide minerals are commonly found on joints. Joints are planar structures and we can measure their strike and dip. In any area, there are commonly one or more directions or sets of joints.

FAULTS

Faults are breaks in rocks with noticeable movement or **displacement** of the rocks on either side of the break. Most faults are planar structures, so we can measure the strike and dip of a fault.

Faults are important because a very large number of mineral deposits are found filling openings in rocks created by faults or replacing rocks on either side of faults. These are usually referred to as **veins**. Faults are frequently the passageways along which mineralizing solutions travel, so following a fault may lead to a mineral deposit. Faults too, if they occur after mineralization, may break up existing mineral deposits and make it difficult to determine the size or shape of the deposit.

There are various types of faults; they can be classified on the basis of the direction of movement of the displaced rocks:

(1) Displacement mostly vertical (in direction of dip).

(2) Displacement mostly horizontal (in direction of strike).

(3) Oblique faults (some movement in both dip direction and strike direction; this group is rather complex to describe).

Faults are best described with the aid of a series of "before" and "after" diagrams (*see* Figs. 5-4 to 5-8), but first here are some terms that apply to faults regardless of type.

Hangingwall and Footwall — These are old miner's terms; if you are mining along a fault, your feet would be in the footwall side of the fault and the other side would be "hanging" over your head. They are indicated in several of the figures.

Fault Scarp — This refers to that part of the fault surface that is exposed above ground (*see* Figs. 5-4 to 5-8).

Slickensides — These are scratches or polish marks on a fault surface, usually along the direction of the last movement (Fig. 5-9). If you rub your hand back and forth along slickensides, one direction may feel smoother than the other. In theory, the rocks on the same side of the fault surface as your hand, moved in the direction that feels smoothest. In practice, you may not notice any difference, and you should not rely on conclusions about fault movements reached by this test alone.

Fault Breccia — This refers to crushed, angular rock fragments found in a fault zone (Fig. 5-10).

Fault Gouge or Gouge — This is finely crushed or clay-like powdered rock found in a fault zone.

Shear Zone — Many faults affect a width of rock rather than being a single clean break. The width of affected rock is often called a shear zone or sometimes a **fault zone**. Within a shear zone, the rock may be broken up into parallel slabs or into a breccia or gouge.

Stringers — These are narrow veins or veinlets, often parallel to each other and often found in a shear zone.

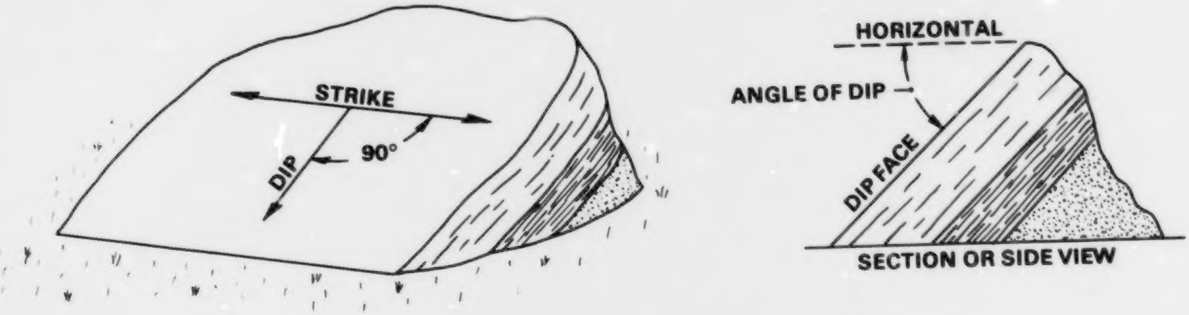


Figure 5-3. Outcrop of sedimentary rocks showing strike and dip.

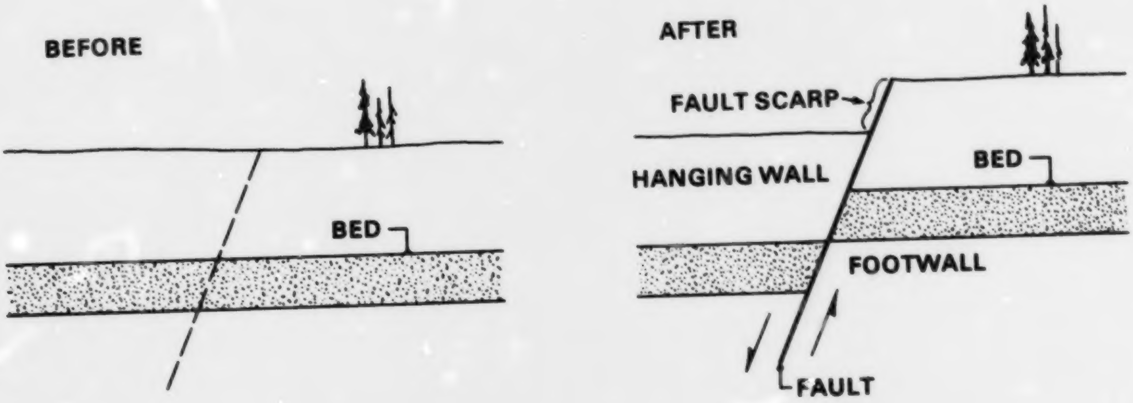


Figure 5-4. Normal fault.

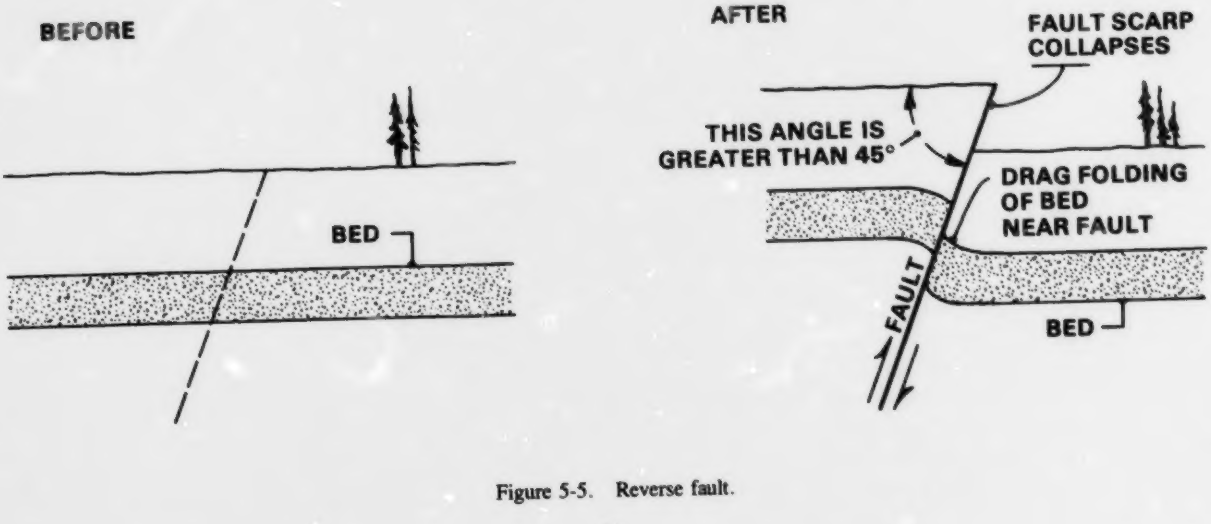

BEFORE
BED
AFTER
FAULT SCARP COLLAPSES
THIS ANGLE IS GREATER THAN 45°
DRAG FOLDING OF BED NEAR FAULT
FAULT
BED

Figure 5-5. Reverse fault.

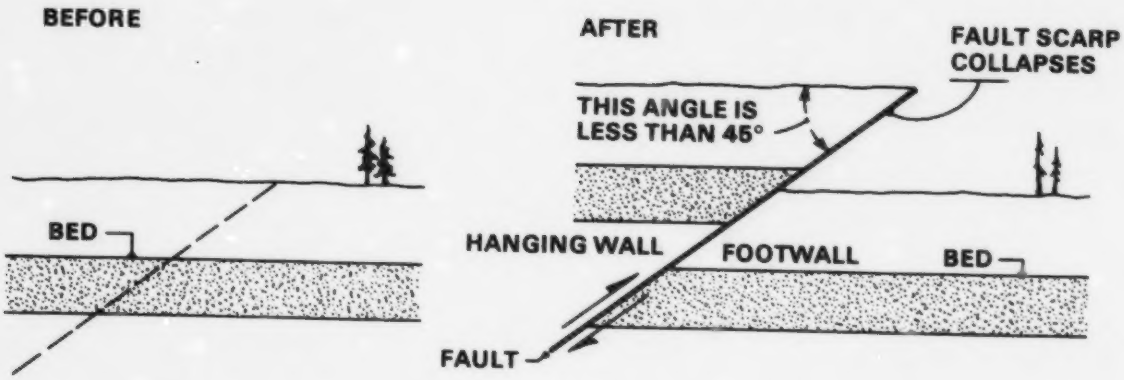
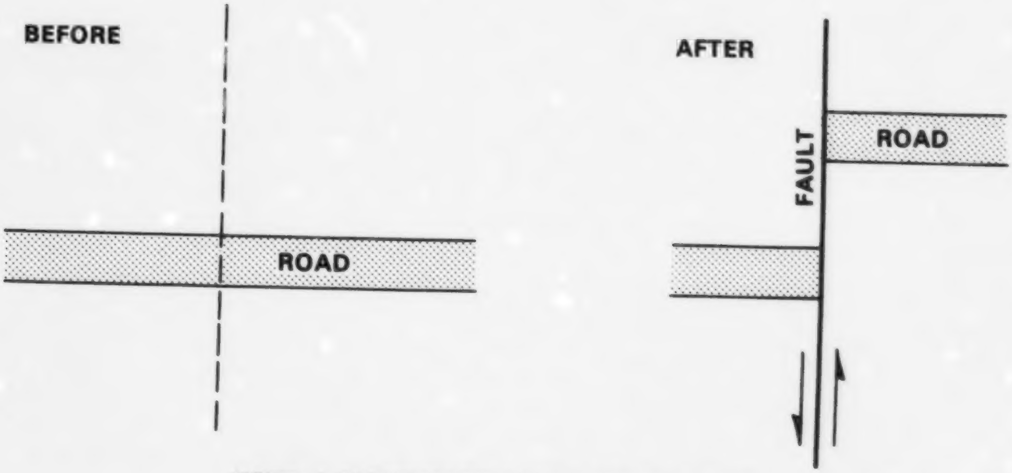


Figure 5-6. Thrust fault.



NOTE: A RIGHT HAND FAULT WOULD HAVE DISPLACEMENT IN THE OPPOSITE DIRECTION

Figure 5-7. Left hand fault (plan view).

RECOGNITION OF FAULTS

One very important point to remember about locating faults is that geological maps on some scale are available for most areas. There is a very good chance that major faults in any area are known and have already been mapped. Before you go prospecting you should have some idea what types of faults to expect, and you can get this by looking at geological maps.

Faults usually form patterns that follow one or more directions in any particular area; thus you should check these directions when you are in the field. Remember, just because faults have been mapped, it does not mean that every metre of every fault has been examined by geologists or prospectors, nor does it mean that all the faults have been located.

The following features may be spotted on topographic maps and air photographs, and may indicate the presence of faults:

(1) Lineaments — Maps and air photographs often show topographic features running fairly straight and often in the same general direction or directions. These lineaments are often caused by faults and sometimes by large-sized joints. Examples are:
   (a) Long narrow lakes.
   (b) Long straight stretches of streams.

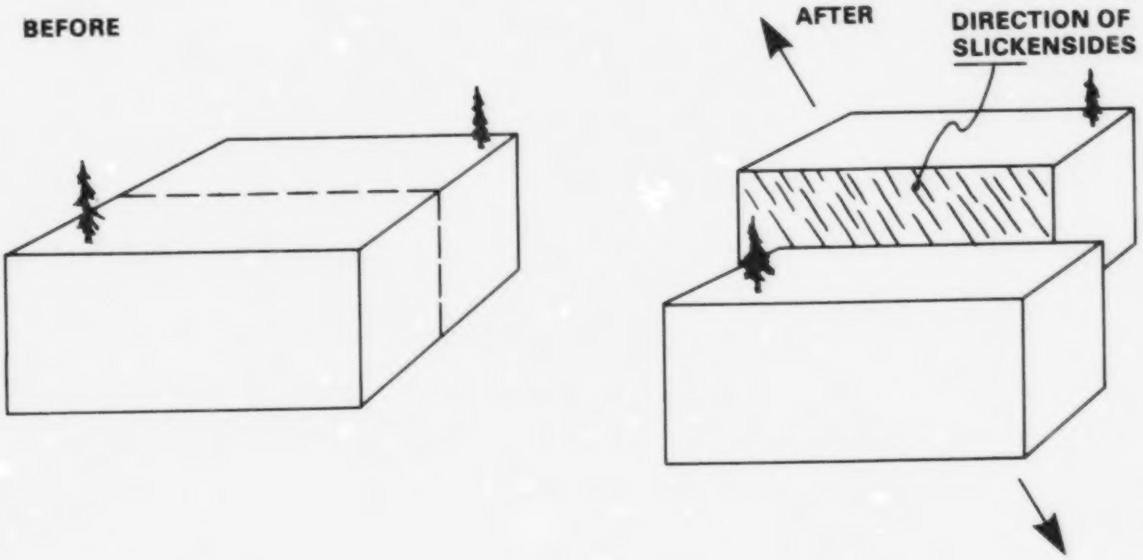


Figure 5-8. Fault with oblique movement.

(c) Cliffs or escarpments.
(d) Straight or very regular shorelines.

(2) Offset Topography — Hills or ridges which suddenly end or are offset and rivers which suddenly change direction may be cut by faults.

(3) Sudden changes in the contours on geophysical maps such as magnetic or VLF maps.

The following may be observed more readily on the ground:

(4) Offset bedding, or rock units such as beds which end abruptly.

(5) Unlikely rocks side-by-side, for example, sedimentary rocks close to schists or gneisses, may be separated by a fault.

(6) Elongated depressions in the ground.

The following may be observed on or near outcrops:

(7) Dragfolding; bedding for example may bend as it approaches a fault (*see* Fig. 5-11).

(8) Slickensides.

(9) Fault breccia or fault gouge.

(10) Patches of minerals such as quartz or calcite on rock surfaces.

(11) Stained or altered rock (*see* gossans and wallrock alteration in the next chapter).

(12) Angular fragments of quartz or calcite or mineralized rock as **float** (meaning loose) in an area, such as in a creek bed (note that rounded pebbles or boulders of quartz or mineralized rock have been smoothed by erosion, and probably are not of local origin).

FOLDS

When forces are applied gradually to rocks over a long period of time, the rocks may fold instead of breaking or faulting. Figure 5-12 is a "birds-eye" view of a fold sticking up out of a level surface.

The **axis** of a fold is an imaginary line, in this case along the top or **crest** of the fold. An axis can also mark the bottom or **trough** of a fold. You can think of the axis as an imaginary hinge line about which the fold limbs are bent. The axis of a fold may be tilted, not horizontal. The fold is then said to be **plunging** and the **angle of plunge** of a fold can often be measured or estimated.

The commonest types of fold are the **anticline** and the **syncline**, which generally occur as pairs (*see* Figs. 5-13, 5-14, and 5-15).

UNCONFORMITIES

If a land surface that is subject to erosion should become submerged beneath the sea, then sediments will accumulate on it and eventually form sedimentary rocks. This covered erosion surface is called an **unconformity** (Fig. 5-16). There are several types of unconformities, but the important point about them is that they represent a break in the rock record, where rocks are missing because at some time in the past they have been eroded.

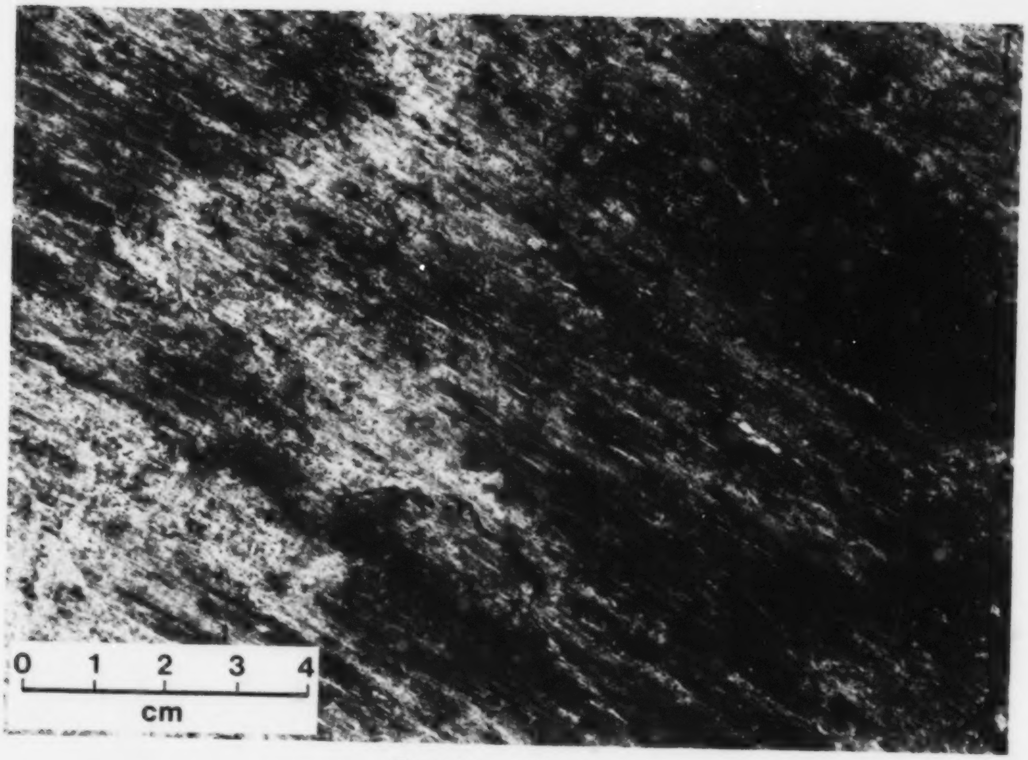


Figure 5-9. Slickensides.

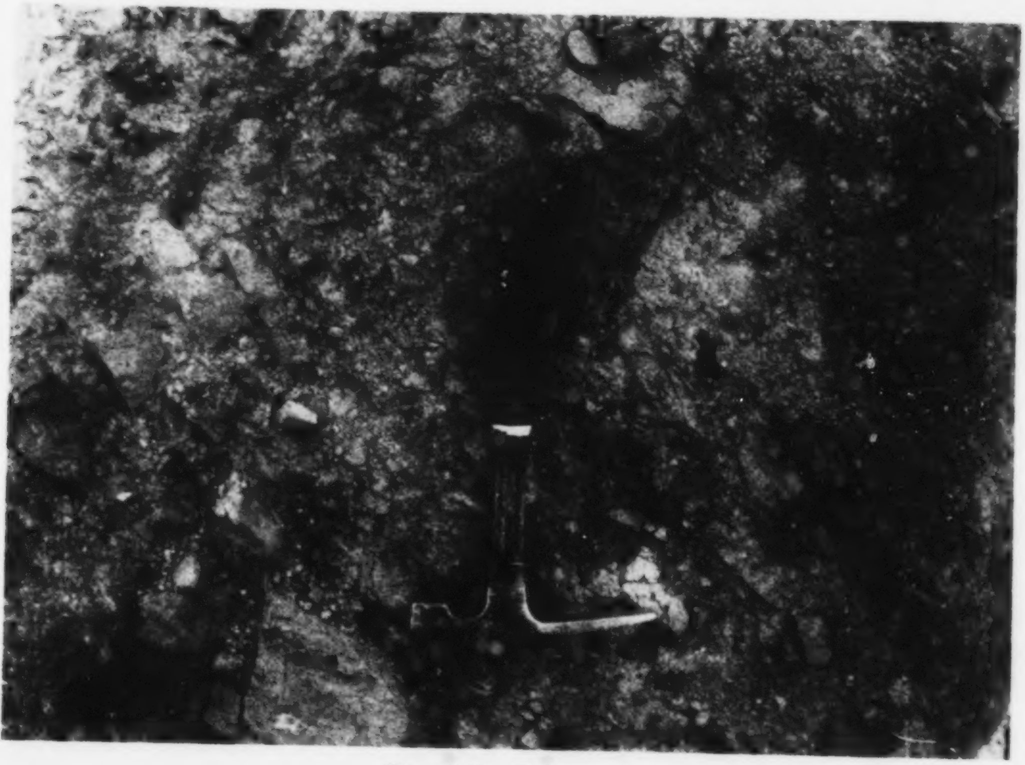


Figure 5-10. Fault breccia.

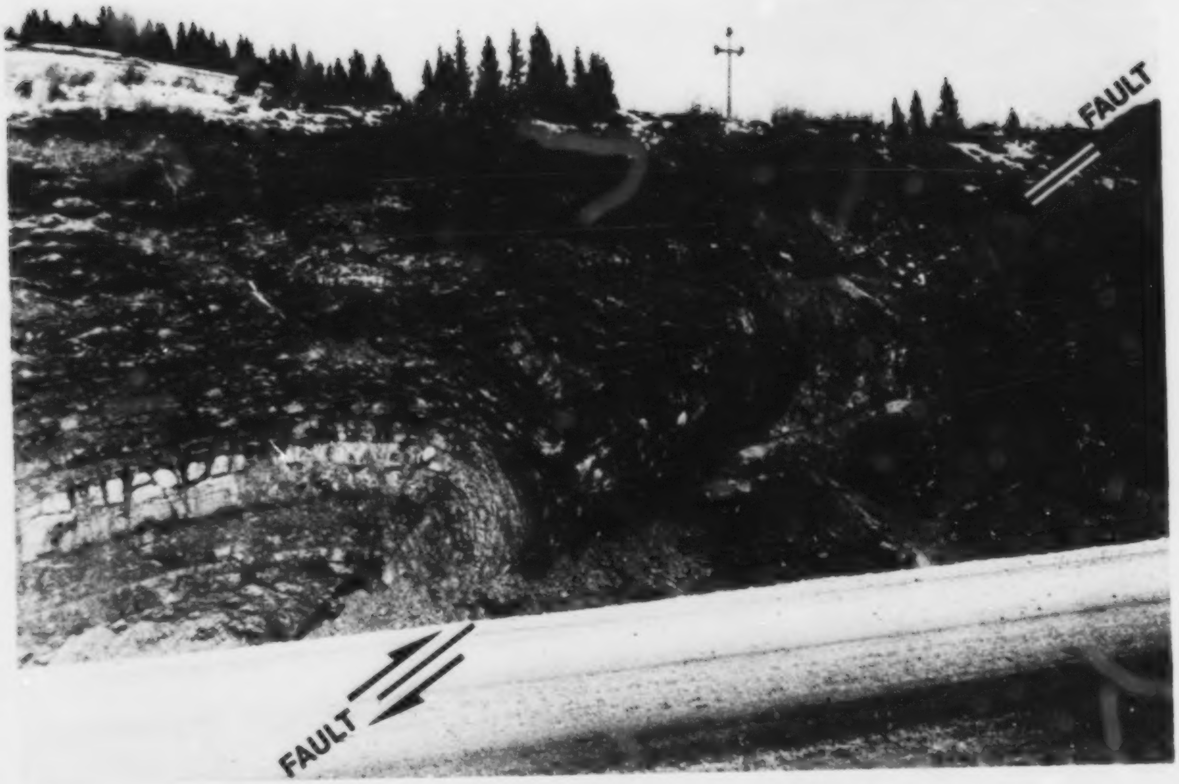


Figure 5-11. Dragfolding on a reverse fault. — D. Grieve

CONCLUSION

A lot of information has been covered in this chapter. Most important for the prospector are the parts dealing with faults and igneous features, because of the relation these have with many mineral deposits. The terms introduced in this chapter will occur frequently in chapters to follow, as well as in geological reports.

ADDITIONAL NOTES

For those who are interested, some additional features are included. Do not worry about these on your first time through this chapter.

Pillow Lavas — These are lavas consisting of a large number of characteristic pillow-shaped and pillow-sized lumps of lava squashed together (Fig. 5-17). The margins of the pillows are usually lighter in colour and finer grained than the centres. The most likely rocks to show this structure are basalts and some andesites.

The importance of pillow lavas is that they are only formed under water. Geologists now believe that many massive sulphide deposits found in volcanic rocks are formed when solutions and gases escape from submarine volcanoes and react to form sulphide deposits at or near the sea floor (around the so-called "black smokers"). The presence of pillow lavas will tell you that you are looking at submarine volcanic rocks.

Faults — When faults pass through rocks of different strengths or composition, they frequently change direction slightly. As can be seen from Figure 5-18, this may lead to an opening suitable for mineralization. Note the diagram could apply to a vertical (normal) fault or a horizontal (left-hand) fault.

Faults can do unexpected things to veins or beds. Here are just three examples (*see* Figs. 5-19, 5-20, and 5-21).

Folds — Here are some figures (Figs. 5-22 to 5-25) illustrating different types of folds; all these figures show cross sections of the folds. The dashed line marks the position of what is known as the **axial plane** — an imaginary plane or surface passing through the axis which divides the fold into roughly mirror-image halves.

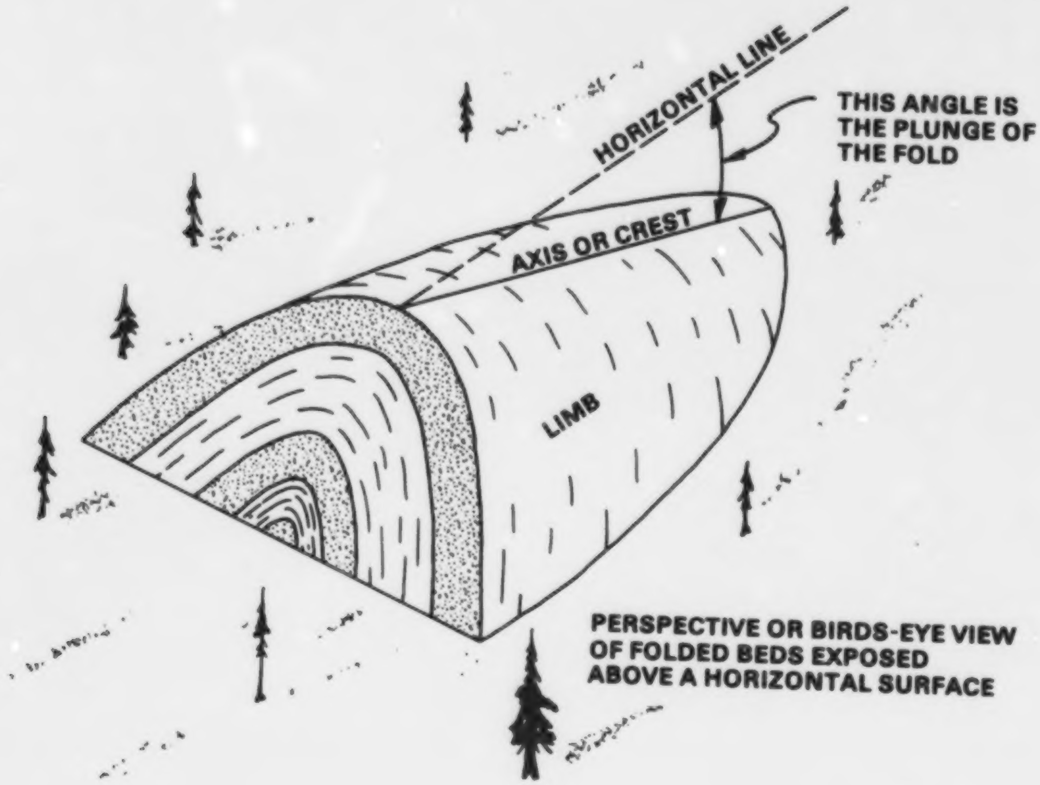

HORIZONTAL LINE
THIS ANGLE IS THE PLUNGE OF THE FOLD
AXIS OR CREST
LIMB
PERSPECTIVE OR BIRDS-EYE VIEW OF FOLDED BEDS EXPOSED ABOVE A HORIZONTAL SURFACE

Figure 5-12. Geometry of a fold.

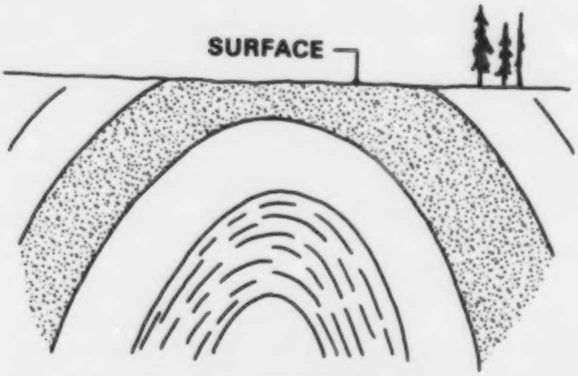


Figure 5-13. Cross section of an anticline in sedimentary rocks.

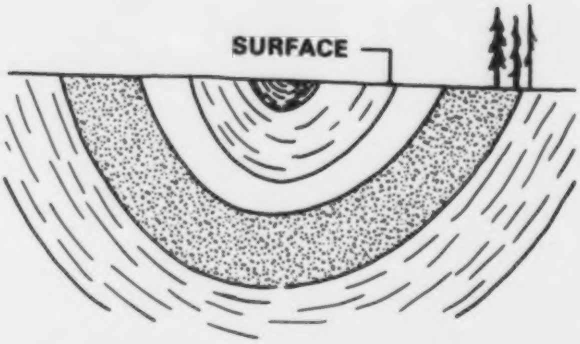


Figure 5-14. Cross section of a syncline in sedimentary rocks.

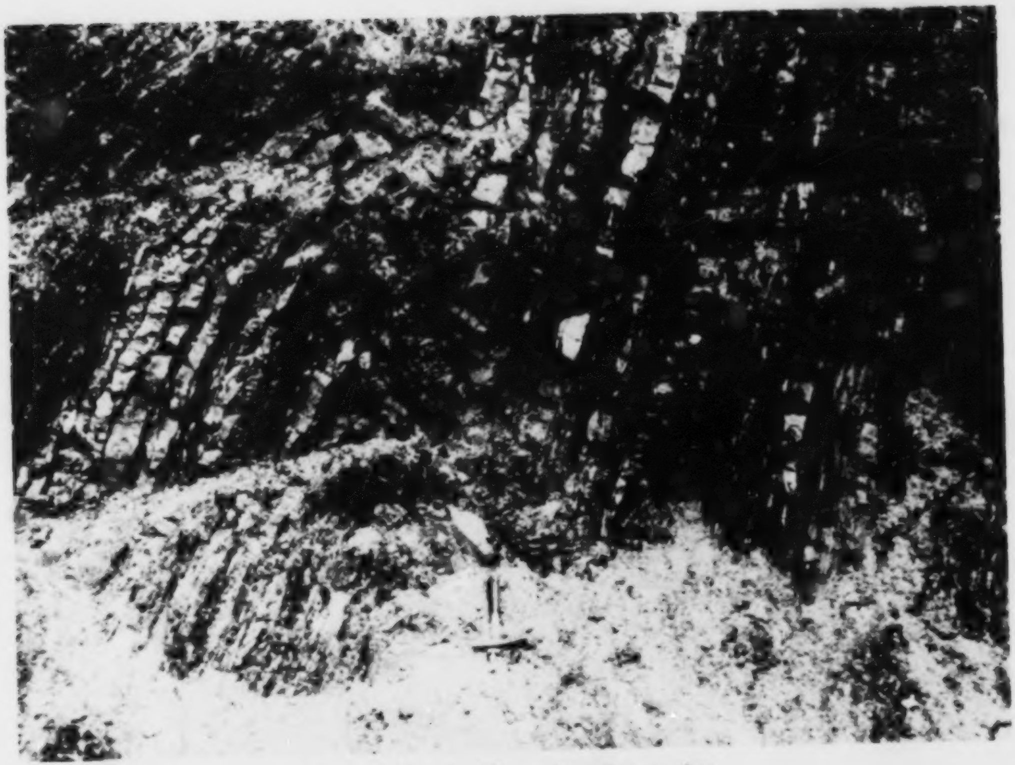


Figure 5-15. Anticline and syncline together.

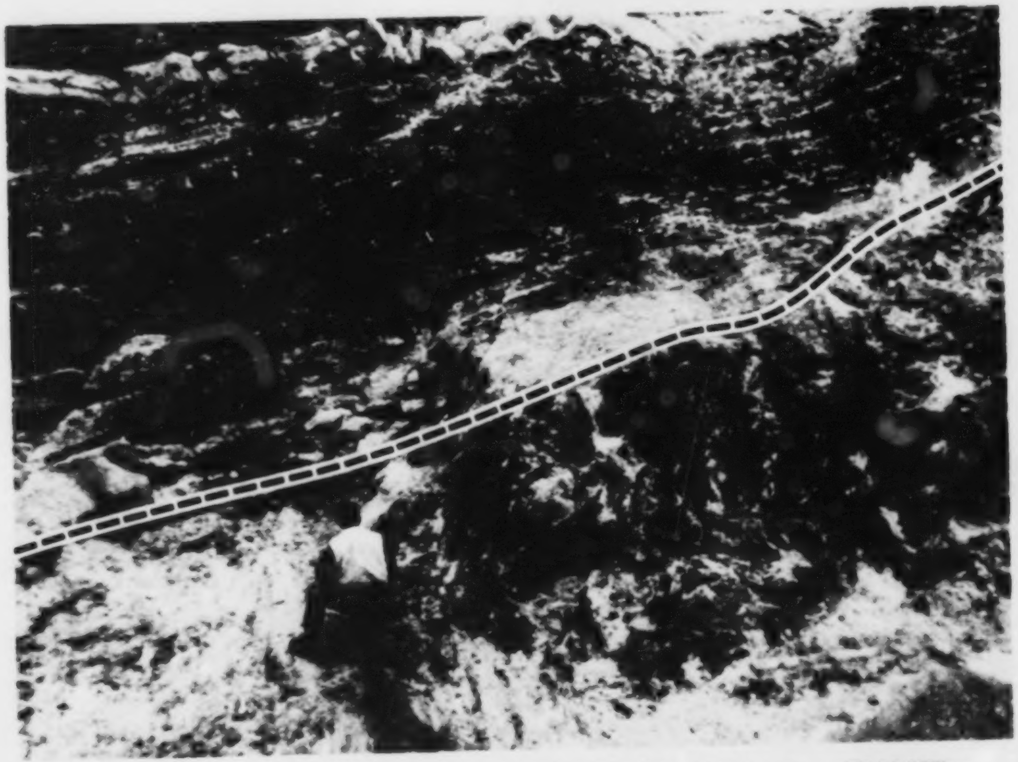
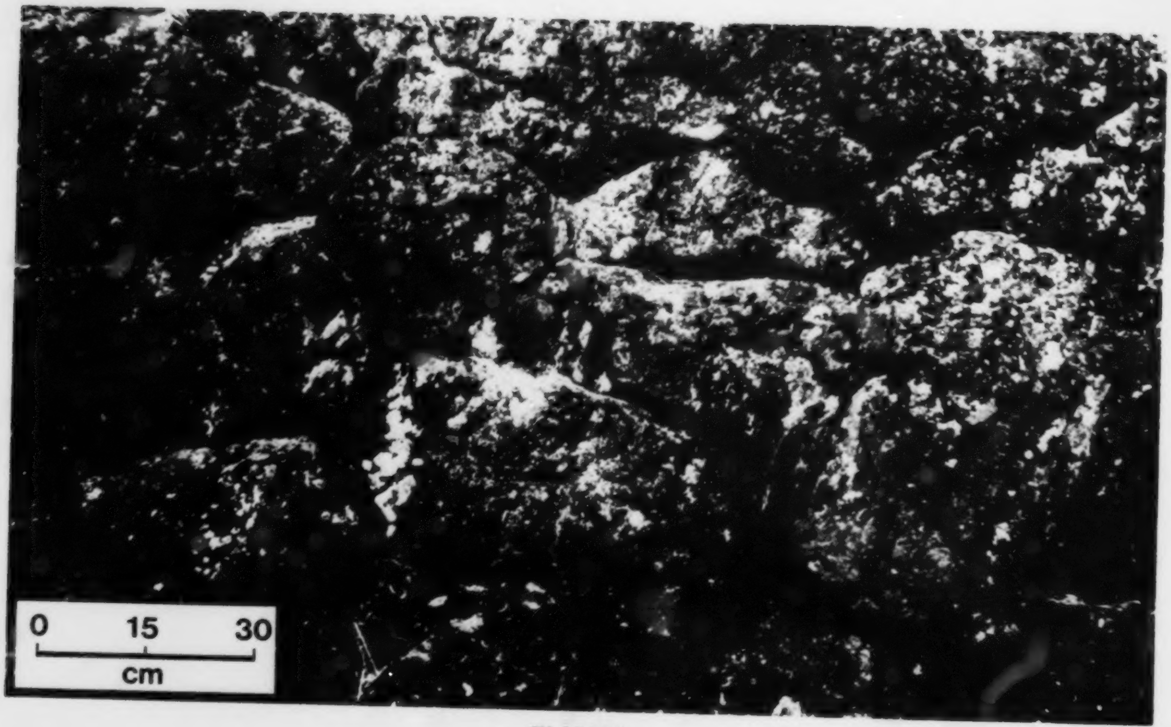


Figure 5-16. Unconformity — younger sedimentary rocks above older volcanic rocks. — W. McMillan



— W. McMillan

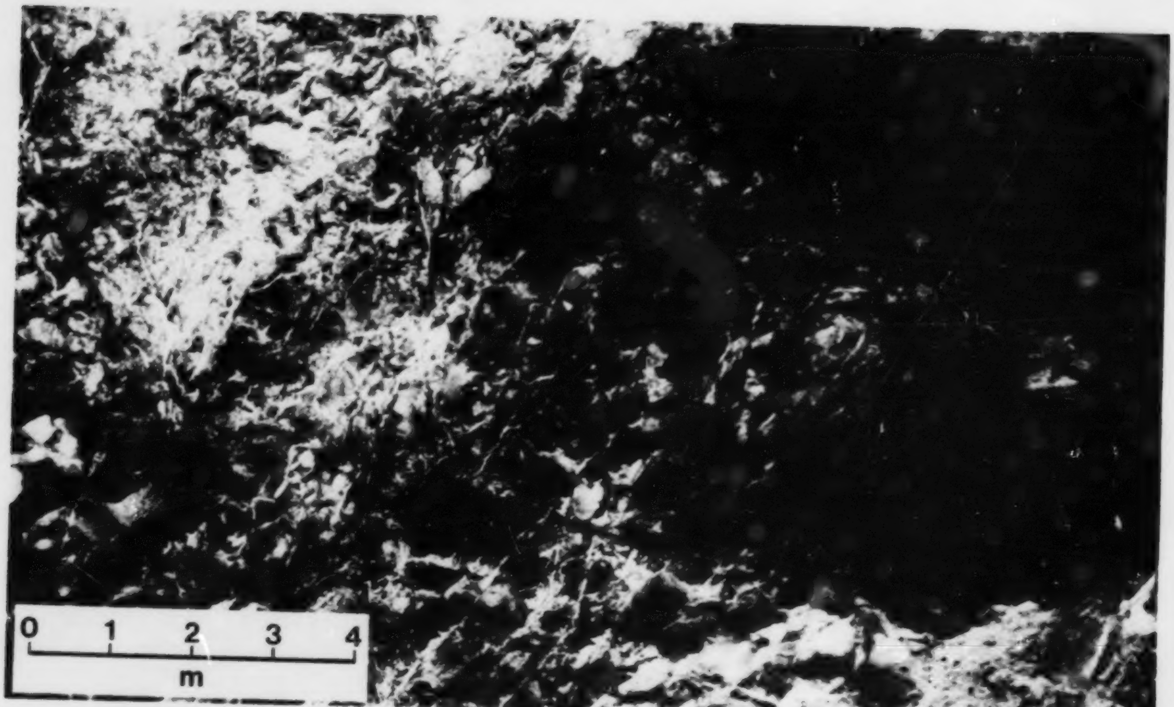


Figure 5-17. Pillow lavas. (Above: undeformed and unaltered. Below: slightly deformed and altered.)

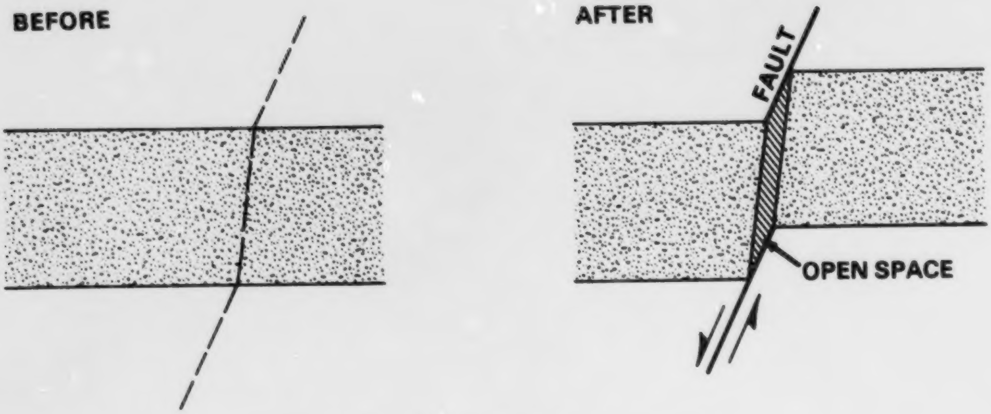


Figure 5-18. Opening created by fault movement.

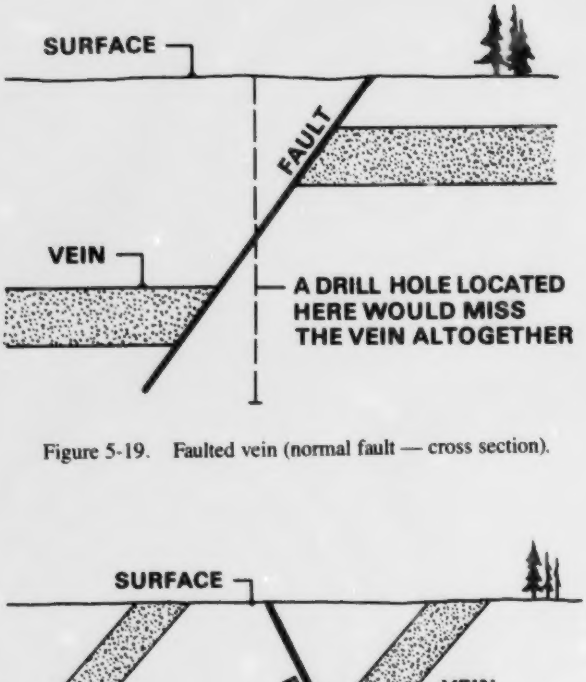


Figure 5-19. Faulted vein (normal fault — cross section).

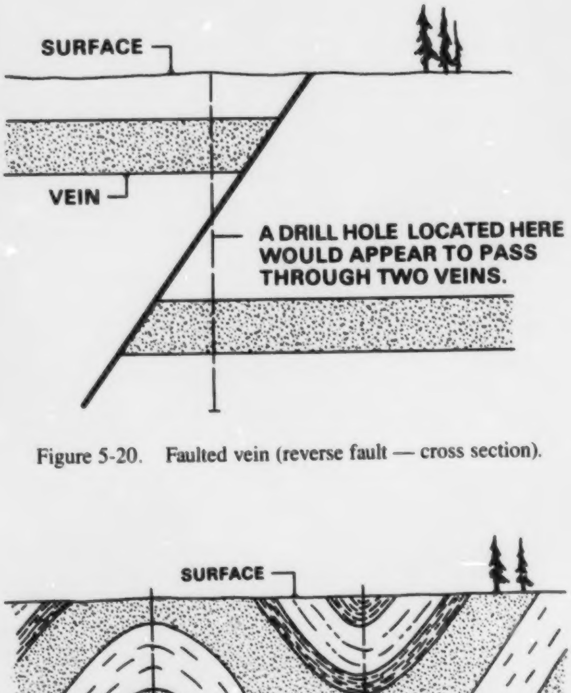
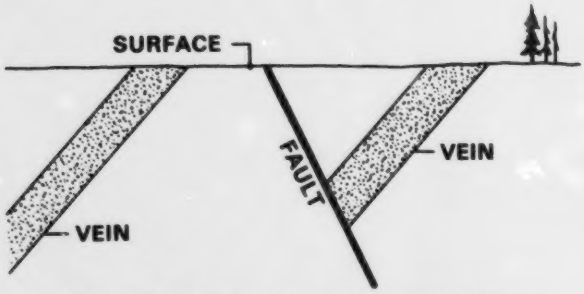

SURFACE
VEIN
A DRILL HOLE LOCATED HERE WOULD APPEAR TO PASS THROUGH TWO VEINS.

Figure 5-20. Faulted vein (reverse fault — cross section).



TILT AND ERODE THE FAULTED VEIN SEEN IN FIGURE 5-20 AND YOU WOULD FIND TWO VEINS OUTCROPPING ON THE SURFACE

Figure 5-21. Faulted vein (cross section).

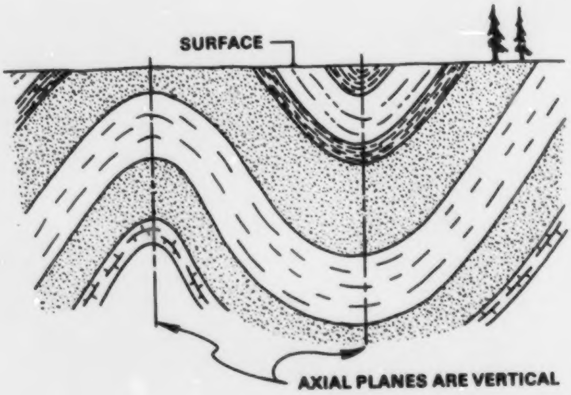
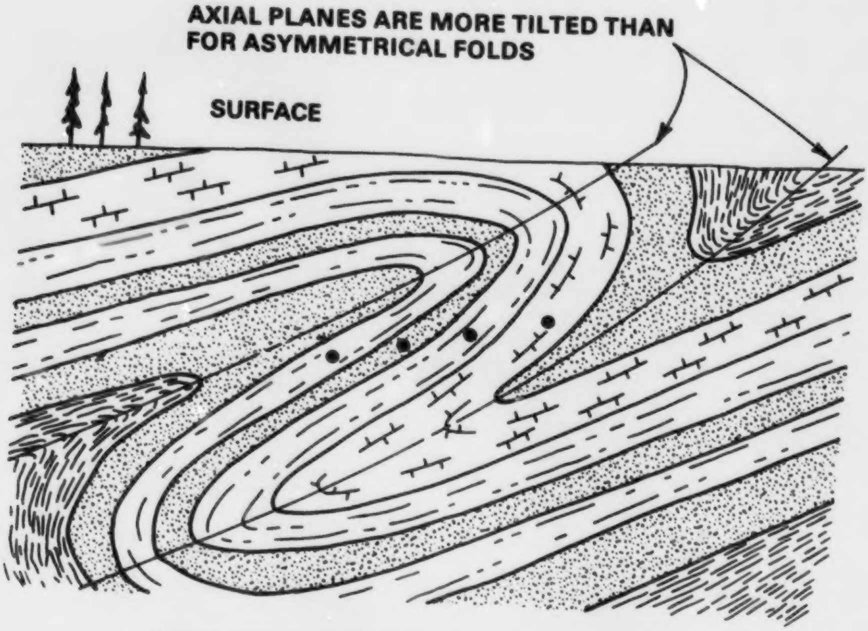


Figure 5-22. Simple or symmetrical folds.



NOTE: BEDS MARKED WITH A BLACK DOT ARE OVERTURNED (THE ORIGINAL TOPS NOW FACE DOWNWARD)

Figure 5-24. Overturned folds.

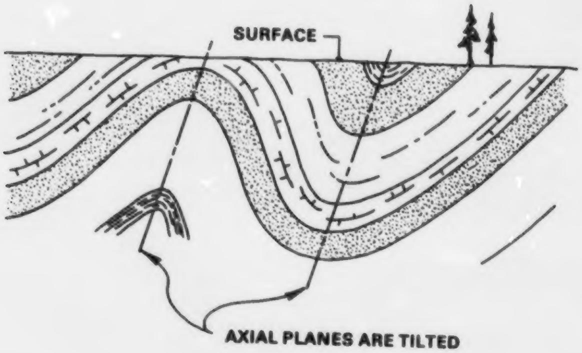


Figure 5-23. Asymmetrical folds.

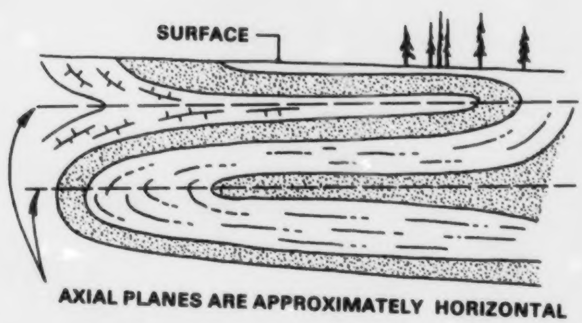


Figure 5-25. Recumbent folds.

CHAPTER 6 — MINERAL DEPOSITS

INTRODUCTION

This chapter deals with mineral deposits and gives an outline of the various types of deposits, the metals or minerals they usually contain, the type of rocks that they are frequently associated with, areas considered to be "favourable" for certain types of deposit, and signs of mineralization to look for in the field. A brief section on sampling and some Additional Notes on the treatment of assay results are also included.

THE FORMATION OF MINERAL DEPOSITS

Every element occurs in the earth's crust distributed throughout different rocks in a range of concentrations considered "normal" or "average". Rarely however, can an average rock be mined. For example, 1 cubic kilometre of the most barren rock contains over 1 300 kilograms of gold (nearly 42,000 troy ounces) — if you could only get it out! What is needed is some kind of natural concentration process to give an unusual concentration of the desired element. When this happens we have a mineral deposit.

TERMINOLOGY OF A MINERAL DEPOSIT

There are a large number of terms used to describe mineral deposits. Some of these you have no doubt heard of. Most of them can be understood with the aid of Figure 6-1 which shows a section through a vein and Figure 6-2 which shows a number of different types of mineral deposits.

Gossan — When a mineral deposit weathers, most of the minerals are broken down. Some of the break-down products are removed from the surface, while others form a mass of new minerals called a **gossan** (Fig. 6-5). Typical minerals of gossans are the iron oxides — limonite and hematite — mixed with clays and remains of weathered rock. Other minerals, such as malachite and azurite, may be present. Because of the concentration of iron oxides, gossans often form brown, red-brown, or yellow-brown rock masses or soils.

In British Columbia, glaciation has undoubtedly removed many gossans and in the limited time since glaciation new ones have only just started to form. For this reason, any heavily stained rocks should be checked; they may mark the site of mineralization. A list of stain colours and their possible significance will be given later.

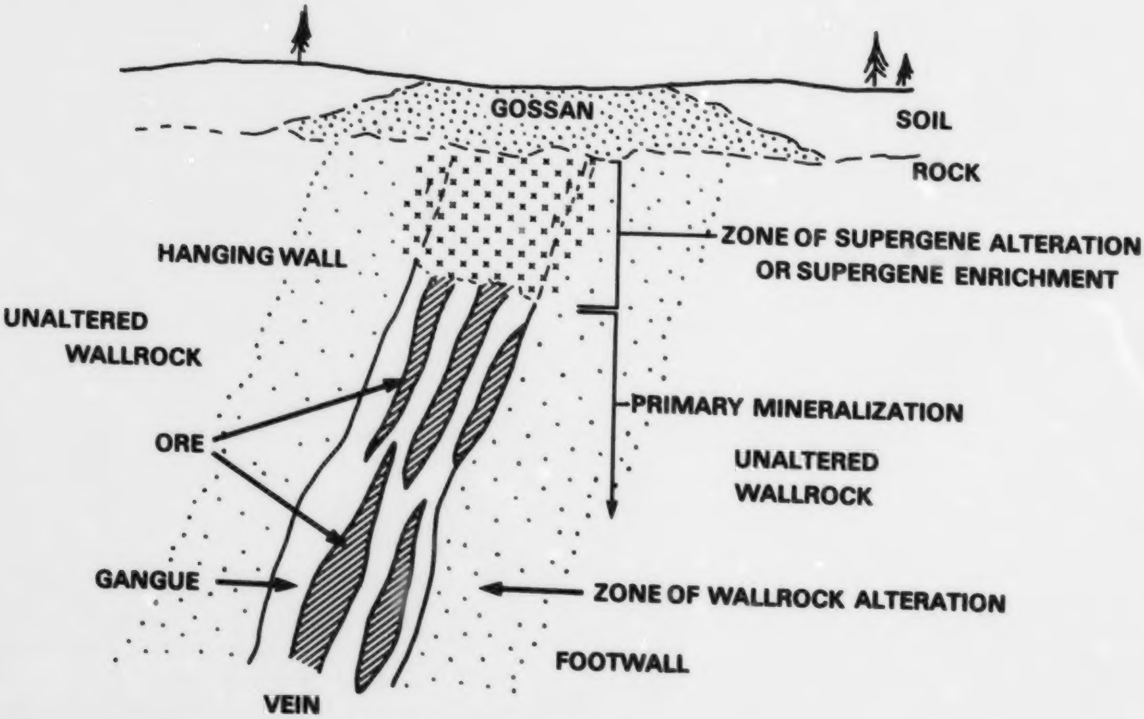


Figure 6-1. Cross section of a vein.

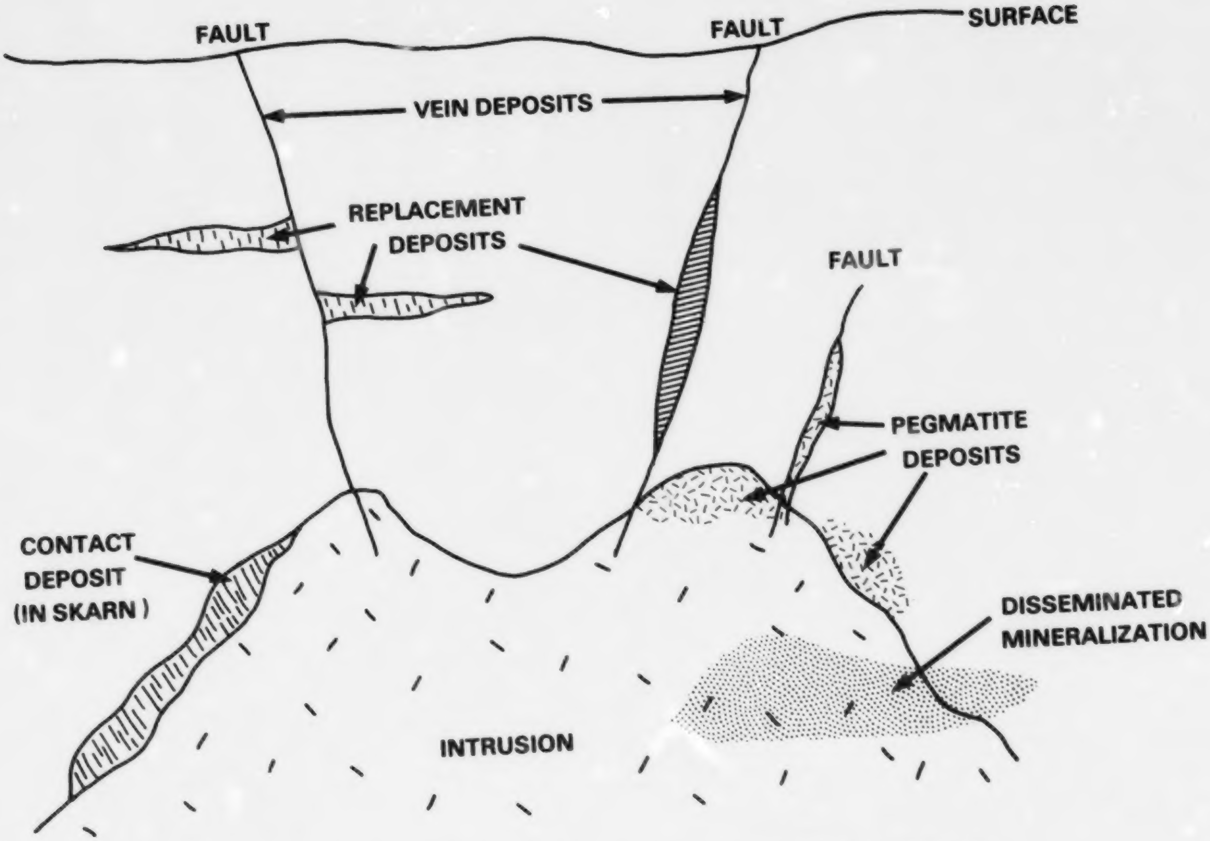


Figure 6-2. Types of mineralization that may be associated with an igneous intrusion.

Supergene Alteration or Enrichment — These terms apply to processes that may take place in a zone beneath a gossan or the bedrock surface. The break-down products of weathered minerals may react chemically with mineralization in this zone causing changes in the minerals present — **supergene alteration**. Sometimes this leads to increases in the concentrations of metals in the zone — **supergene enrichment**. Minerals often found in supergene enrichment zones are bornite, chalcocite (a soft, sooty black copper sulphide), native copper, and sometimes native gold and silver. Probably because of climate and glacial history, supergene alteration or enrichment is not usually common or extensive in British Columbia, although there are some notable examples, such as the Afton copper deposit and the Gibraltar copper-molybdenum deposit where preglacial zones have been preserved.

Primary Mineralization — This is the original mineralization, unaffected by weathering or supergene processes. In British Columbia primary mineralization is often found right at the surface.

Ore — The old prospector's definition of ore as a "rock worth mining" is still to the point and hard to beat. Miners have to make money.

Ore Shoot — This is a part of a mineral deposit that contains ore grade material.

Gangue — This term describes worthless minerals or rock waste mixed in with the valuable minerals. Calcite, quartz, and pyrite are common gangue minerals. Gangue minerals usually have to be mined with the ore, so they add to the cost of mining.

Wallrock Alteration — The rocks surrounding a mineral deposit are often chemically altered during mineralization. This alteration may extend considerable distances from the deposit, so any extensive alteration that you can spot in the field should be checked as it may lead you to mineralization.

Vein Deposit — This is a deposit that is narrow compared to its length and depth. Most vein deposits occur in fault openings or in fault or shear zones.

Replacement Deposit — This is a deposit formed by mineralization that penetrates and replaces rock material. Replacement deposits are often found in or near faults but also occur at the contact of some intrusions, or within particularly "favourable" rock units.

Massive Deposit — This term describes a deposit that contains a very high percentage of a mineral or minerals, and usually has an irregular to compact shape.

Disseminated Deposit — This is one in which the mineralization is scattered through a large volume of host rock, sometimes as separate mineral grains or sometimes along joint or fault surfaces. Disseminated deposits may be very large in size, but are usually of low grade.

MINERAL OR METAL ASSOCIATIONS

Because of chemical and geological factors, some metals tend to occur together in mineral deposits, while others may be found associated with a particular rock type. The following are the more important mineral or metal associations:

(1) The following associations may be found within a deposit:
   (a) Galena with sphalerite, or copper sulphides with galena or sphalerite or both.
   (b) Copper sulphides with molybdenite.
   (c) Gold and minor sulphides in quartz veins; this is the "classic" occurrence of native gold.
   (d) Gold with arsenopyrite; the gold is rarely visible and other sulphides may be present.
   (e) Gold with pyrite; again the gold is rarely visible and minor amounts of other sulphides may be present.
   (f) Silver with galena and galena-sphalerite mineralization; the silver is almost always contained in the galena but may be present as small amounts of silver minerals.
   (g) Silver with tetrahedrite or other copper-antimony or copper-arsenic sulphides.

   The last five examples illustrate an important point about mineral deposits: it is not always the most abundant mineral in a mineral deposit that has value. Any sizeable quartz veins containing some sulphides, such as arsenopyrite, pyrite, galena, sphalerite, or tetrahedrite mineralization should be assayed for gold and silver.

(2) The following types of mineralization may be associated with particular host rocks:
   (a) Molybdenum and copper-molybdenum mineralization with porphyry intrusions; valuable traces of gold and silver may also be present.
   (b) Iron and iron-copper-lead-zinc in skarns.
   (c) Lead-zinc in limestones.
   (d) Lead-zinc-silver-barite in shales.
   (e) Copper or copper-lead-zinc with volcanic rocks.
   (f) Nickel with pyrrhotite in gabbros and ultramafic rocks.
   (g) Tin and tungsten with granite intrusions.
   (h) Tungsten in limestones or calcite-bearing rocks near granite intrusions.
   (i) Chromite in large ultramafic intrusions.
   (j) "Rare-earth" minerals with carbonatites; carbonatites are uncommon igneous rocks containing much calcite.
   (k) Uranium with granites.
   (l) Uranium in sandstones and shales.

VISUAL INDICATIONS OF MINERALIZATION

Here is a list of visible signs that may indicate the presence of mineralization:

(1) = In areas where outcrops are present; (2) = In areas where outcrops are rare or absent.

(1) Presence of obvious mineral concentrations — the easiest sign to interpret! Note this refers to both gangue and economic minerals.
(1) Presence of faults with veins (Fig. 6-7) or other indications that mineral solutions have used the faults as passageways (for example, gangue or traces of economic minerals).
(1) Presence of wallrock alteration, especially near faults.
(1) Presence of weathered minerals or mineral alteration, gossans, or abnormal or unusual staining of rocks or soils overlying mineralized rocks.
(1,2) Presence of formations which appear to weather very rapidly, or rarely, which appear to be unusually resistant to weathering (possible gossans).
(2,1) Presence of float containing mineralization or signs of mineralization (Fig. 6-3).
(2) Peculiar vegetation changes, stream sediment colours, water colouration.
(1,2) Traces of valuable minerals recovered from stream sediments, crushed rock, or overburden by panning.
(1,2) Signs of previous prospecting activity — like pits, trenches, staking. If the signs of activity are extensive, there is a good chance that there will be a record of it or your District Geologist will be aware of it (*see* Fig. 6-4).

COLOUR STAINS AND THEIR POSSIBLE SIGNIFICANCE

The colours of typical gossans have been mentioned, for example, shades of brown. These colours often result from the weathering of rocks rich in iron or iron sulphides, so they must be checked to see whether they are due to natural weathering of normal rocks or mineral deposits.

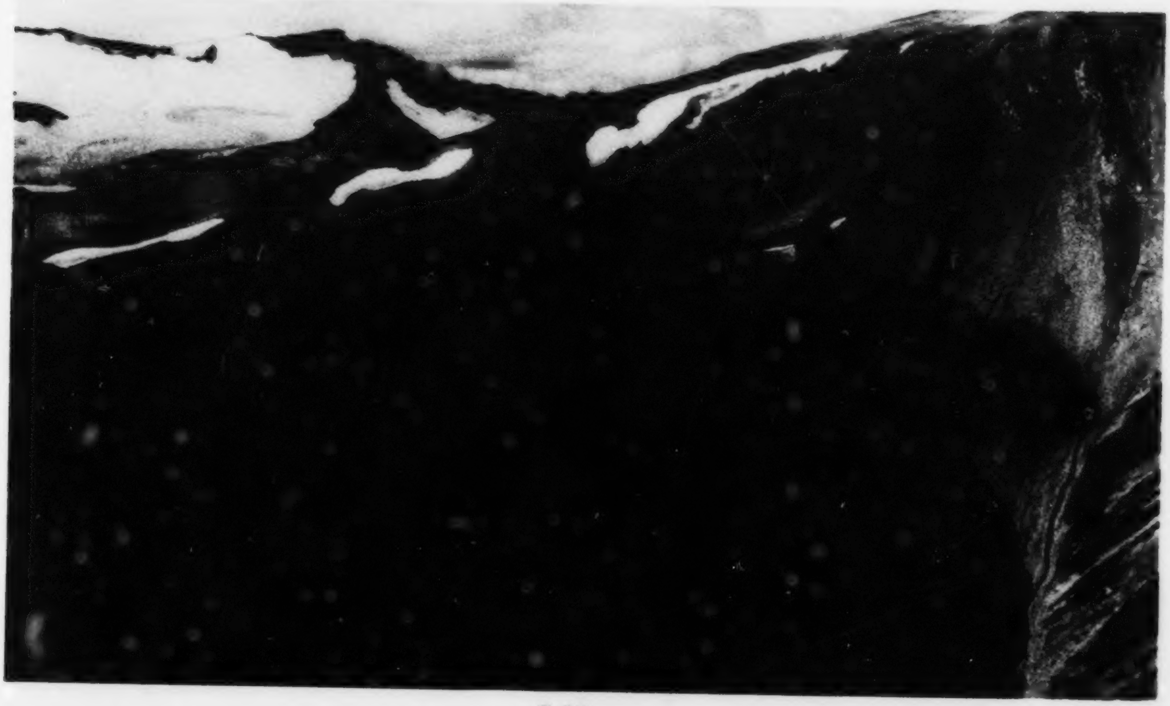
Other stains that should be looked for and investigated are as follows:

(1) Green or blue — due to malachite or azurite, from the weathering of copper minerals (Fig. 6-6).
(2) Yellow — due to weathering of molybdenite; more rarely in British Columbia it may be due to weathering of uranium minerals (Fig. 6-8).
(3) Pink — due to a cobalt mineral called erythrite and sometimes found when base metal or silver mineralization weathers (Fig. 6-9).
(4) Black — often due to weathering of manganese minerals which occur in traces in most rocks, so it may not be significant. Some oxides or sulphides of copper from the weathering of copper minerals are black and, rarely, silver mineralization or native silver may have a black coating or stain (Fig. 6-10).

All stains must be checked closely, as there are a variety of lichens in particular that have colours identical to those caused by mineral stains.

Figure 6-3. Float on a hillside. The float is angular so it is not of glacial origin. The source must be up-slope of this spot (*see* Figure 11-2.)

Figure 6-4. Old mine workings. Old mine workings are dangerous to explore. There will almost certainly be records of workings as elaborate as this. Look around nearby dumps to see what may have been mined.



— T. Schroeter

Figure 6-5. Gossan. (Above: Gossan as seen from the air. Below: Gossan outcrop.)

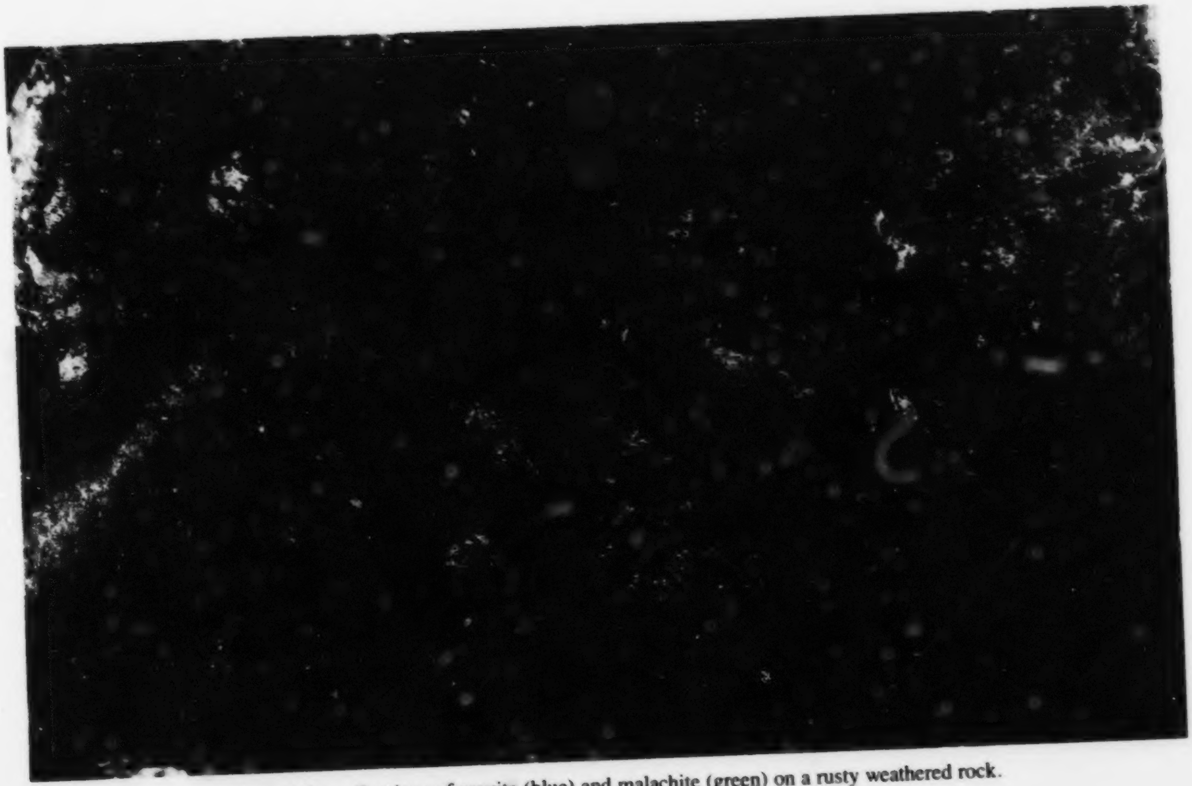


Figure 6-6a. Coatings of azurite (blue) and malachite (green) on a rusty weathered rock.

Figure 6-6b. Crystals and coatings of malachite (green) and azurite (blue) in vuggy copper ore.

Figure 6-7. Limonite-stained quartz vein.

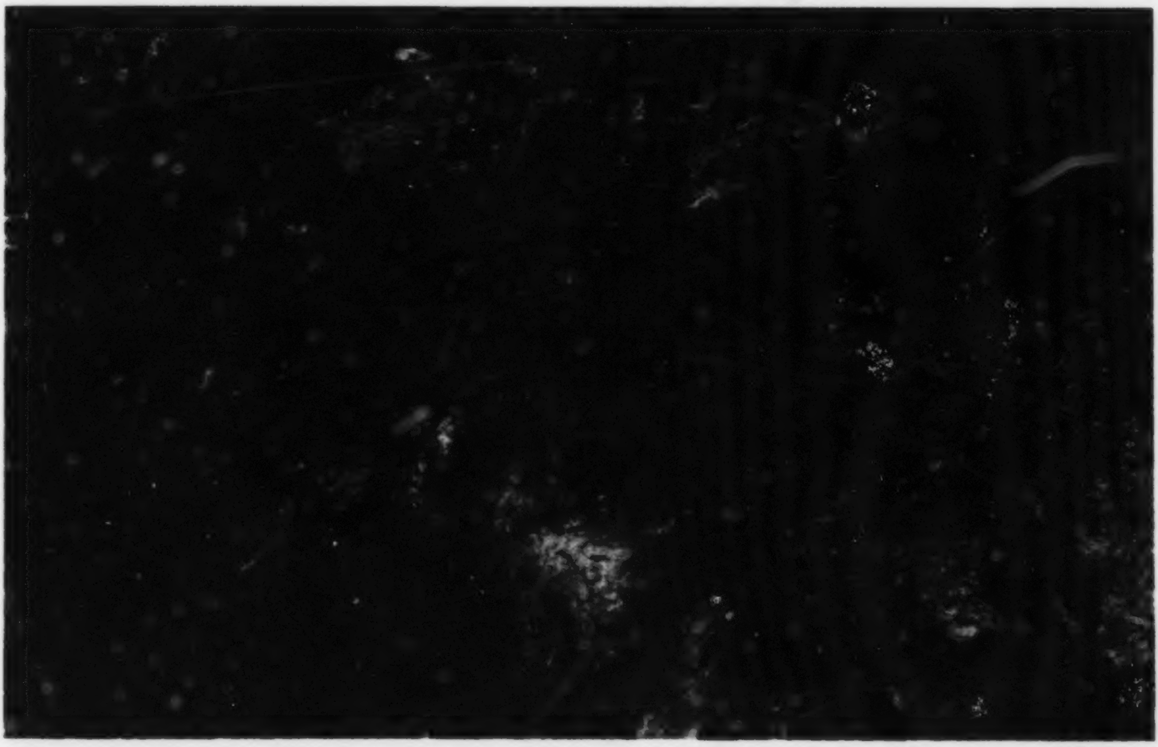


Figure 6-8. Yellow stain on molybdenite mineralization. The yellow is due to a mineral called ferrimolybdite. — T. Schroeter

Figure 6-9. Pink stain (erythrite) on cobalt mineralization. — T. Schroeter

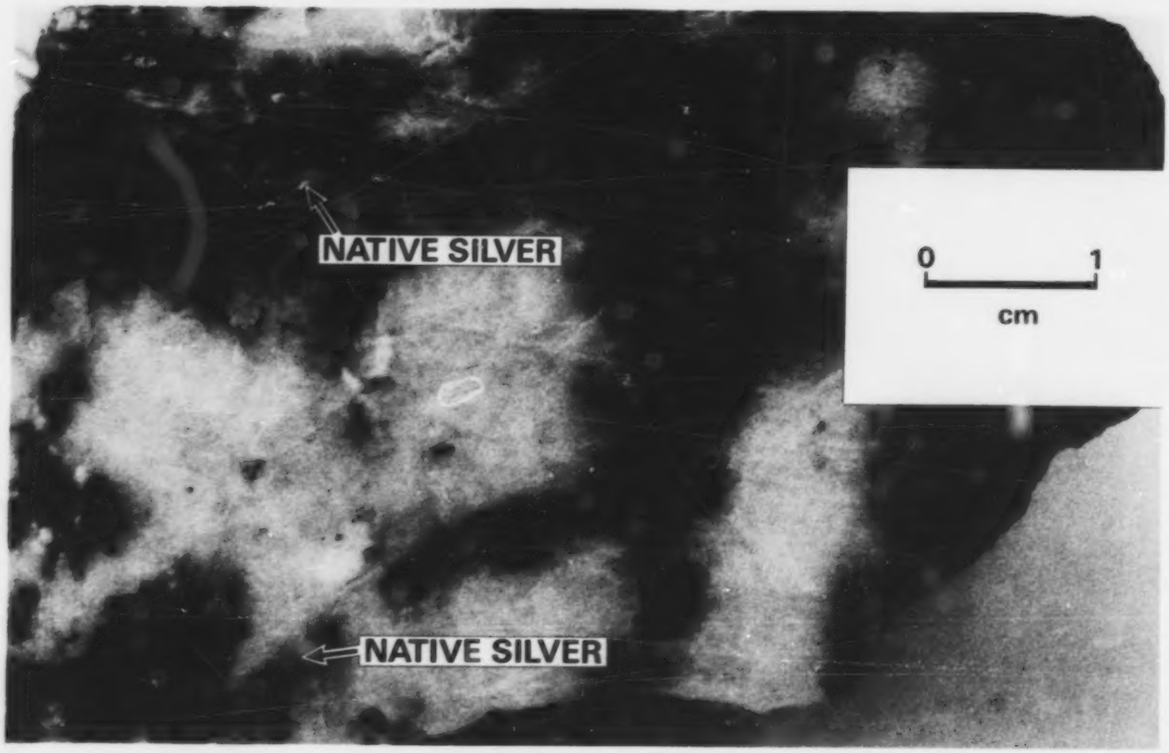
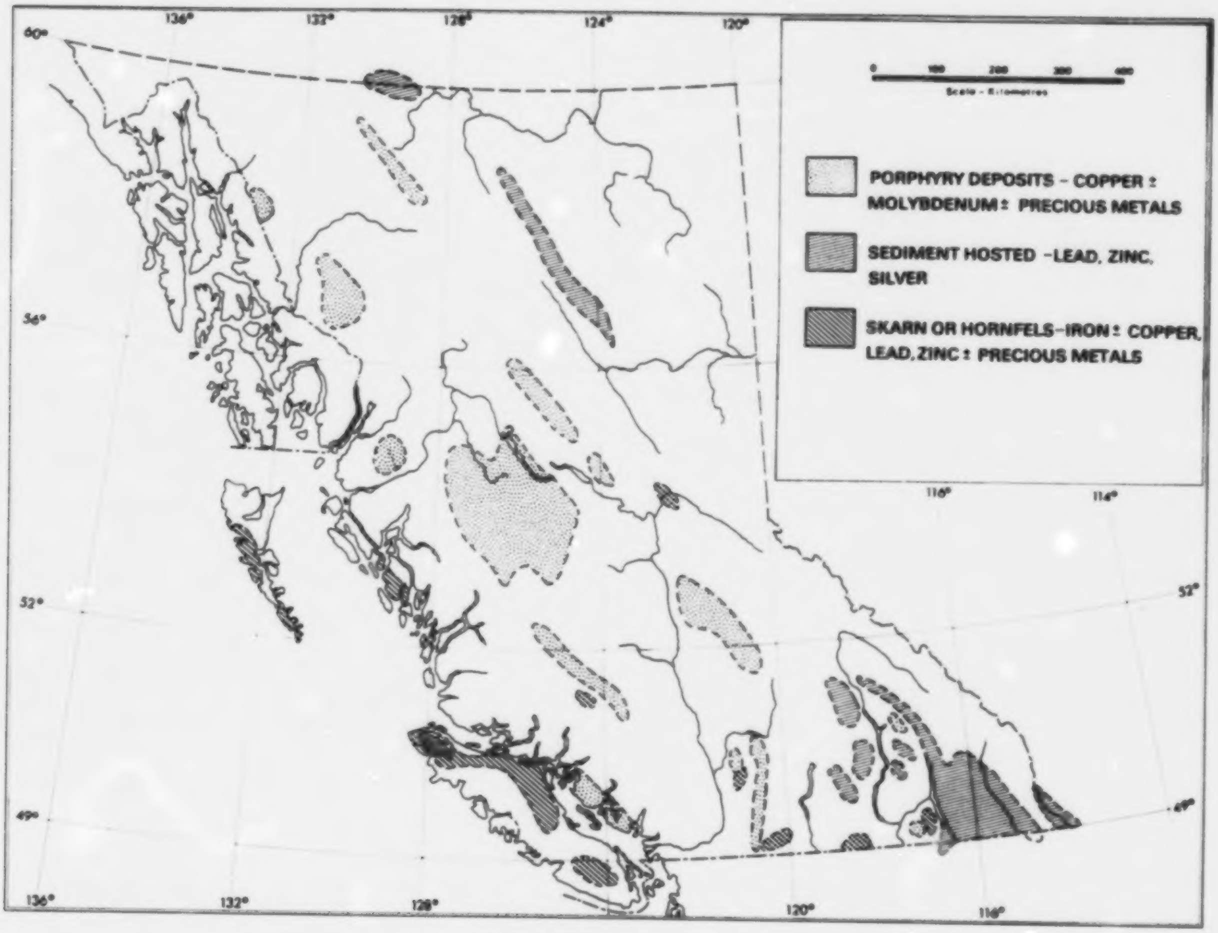


Figure 6-10. Specimen cut to show black stain associated with native silver. — T. Schroeter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52°
49°
116°
114°
0
100
200
300
400
Scale - Kilometres
PORPHYRY DEPOSITS - COPPER ± MOLYBDENUM ± PRECIOUS METALS
SEDIMENT HOSTED - LEAD, ZINC, SILVER
SKARN OR HORNFELS-IRON ± COPPER, LEAD, ZINC ± PRECIOUS METALS

Figure 6-11. "Favourable areas" for mineral deposits — 1.

CLASSIFICATION OF MINERAL DEPOSITS

There are many ways in which this can be done and we cannot go into the subject in any detail. However, a classification scheme is basically a means of grouping together known geological processes, minerals, and mineral-rock associations. One such scheme is given in Table 6-1 and you will see that it includes most of the mineral and rock associations that have already been described. Note that Table 6-1 is not complete; some types of mineral deposit that are rare or unknown in British Columbia have been omitted.

FAVOURABLE AREAS

Outline maps of the province are included which show "favourable areas" for prospecting for deposits of particular metals or minerals (Figs. 6-11 and 6-12). The maps are not meant to be precise or complete, but they do show areas which, because of geological reasons, but more especially because of the number of known deposits, are considered to offer a better chance of success in the search for new deposits. They are a means of improving your odds, but they must not be used rigidly. New discoveries, as well as increased knowledge, will mean changes to the areas now considered "favourable".

Your District Geologist should be consulted for the current opinion on specific areas. He will be able to explain why an area is considered favourable, as well as suggest alternative areas that have perhaps been overlooked or are not so heavily staked as the popular areas.

SAMPLING AND ASSAYING

INTRODUCTION

Probably no other aspect of prospecting is as poorly understood by the average prospector as sampling. As a result a lot of money is wasted on needless or meaningless assays and disappointment or distrust is created when a company geologist is unimpressed by a prospector's seemingly spectacular assay results.

TABLE 6-1. CLASSIFICATION OF MINERAL DEPOSITS

Kind of Deposit	Description	Examples in British Columbia
1. **Magmatic**	Minerals are formed when magma cools and are disseminated or occur in patches or masses, often near the contacts of the intrusion. Minerals often settle through the magma, so are commonly found near the base of the intrusion. Gabbros and ultramafic intrusions are the more common hosts for magmatic deposits.	Diamonds in an ultramafic rock called kimberlite in Golden area. Magnetite and chromite in some gabbros. Copper and nickel sulphides in Hedley area. Niobium and rare earth minerals in some carbonatites.
2. **Pegmatite**	Minerals are formed during final cooling stages of a magma where water and other dissolved gases can accumulate. Crystals may be very large, usually common silicates, occasionally rarer minerals. Most often associated with granite intrusions. Most pegmatites in British Columbia are common silicates.	Muscovite mica in Clearwater area.
3. **Hydrothermal**	Most common and varied group. Minerals (a) fill fractures and openings created by faulting in igneous intrusions or nearby host rocks, or replace rock material along faults or contacts with various "favourable rocks", (b) accumulate near submarine volcanic vents, (c) accumulate in sedimentary rocks as a result of chemical reactions in seafloor environment.	
3a (i). Vein Deposits	These are usually divided into: epithermal — low temperature, shallow depth; mesothermal — medium temperature, moderate depth; and hypothermal — high temperature, great depth. Epithermal veins are usually fracture fillings and hypothermal veins are replacement veins.	Epithermal gold and silver — Toodoggone area, Baker, Lawyers. Epithermal mercury — Pinchi mine. Epithermal-mesothermal silver, lead, zinc — Slocan–New Denver area, Highland Bell.
3a (ii). Porphyry Deposits	Deposits are related to porphyritic intrusions of granite to diorite families. Mineralization occurs as disseminated sulphides, and in joints, fractures, or minor faults in or near the intrusion. Copper, molybdenum, and sometimes tungsten mineralization is usual, but important amounts of gold and silver are sometimes present.	Numerous examples: Highland Valley area, Gibraltar mine (copper, molybdenum), Endako mine (molybdenum), Granisle, Afton (copper), Hudson Bay Mountain (molybdenum, copper, tungsten).
3b. Volcanic Associated Massive Sulphides	Occur in submarine basalt, andesite, or greenstone belts as lenses or irregularly shaped masses containing a high percentage of pyrite and base metal sulphides. Important precious metal values are often present.	Many examples: Western Mines (copper, zinc), Britannia (copper, gold), Windy-Craggy (copper, cobalt).
3c. Sediment-hosted Sulphides	Base metal sulphides often with important silver values occur in sequences of sedimentary rocks. Sulphides are confined to particular beds or groups of beds and deposits vary greatly in thickness and extent. Barite is an important gangue mineral and sometimes reaches ore grade.	Sullivan mine (zinc, lead, silver). Cirque deposit (zinc, lead, silver, barite). Midway area (zinc, lead, silver).
4. **Sedimentary**	These deposits have the properties and associations of sedimentary rocks and consist of concentrations of minerals in beds. (Note: Coal is a sedimentary rock but is not usually considered a mineral deposit.)	Quesnel area (diatomite — a form of porous silica). Some gypsum and other industrial mineral deposits.

TABLE 6-1. CLASSIFICATION OF MINERAL DEPOSITS

Kind of Deposit	Description	Examples in British Columbia
5. **Placer**	Minerals that resist erosion and have a high density accumulate in stream channels and stream deposits. Placer gold is the most important in British Columbia, but some silver and platinum is known.	Cariboo, Omineca, Atlin, Cassiar, many others.
6. **Metamorphic**	Metamorphism may affect existing mineral deposits of all types or cause the formation of new mineral deposits. New deposits are usually restricted to certain rock types or are related to igenous intrusions.	
6a. Contact Metamorphic Deposits	Formed in the contact zone of intrusions and "favourable" host rocks such as limestones, dolomites, or impure calcite-bearing sedimentary rocks. Minerals typically replace the favourable host rocks but sometimes form veins in faults or fractures. Iron oxides and base metal sulphides are the most common minerals, but important amounts of tungsten, molybdenum, precious metals, and other mineralization may be present. Commonly associated with hornfels and skarns.	Salmo area (tungsten), Tasu, Craigmont (iron, copper), Texada Island (iron), Hedley (gold).
6b. Regional Metamorphic Deposits	Certain rock types in areas of regional metamorphism may alter and new mineral deposits may form. Deposits of industrial minerals are the most important of this kind.	Cassiar (asbestos). Cassiar, Ogden Mountain (jade).

SAMPLES AND SPECIMENS

These terms are used very loosely and many "samples" are in fact "specimens". A **sample** is a small amount of material that is supposed to be absolutely typical or representative of the object being sampled. A sample of a vein, for example, assaying 10 grams of gold per tonne should mean that if you mined the entire vein and extracted all the gold, you should recover exactly 10 grams of gold for every tonne of vein — no more and no less. A **specimen** is a piece of rock or mineral taken to show something — the kind of rock from an outcrop, the minerals present in a vein, or the type of mineralization present in a deposit.

Samples and specimens serve different purposes and should be assayed accordingly; you assay specimens (if at all) for information, and samples for quantities. For example, you might assay a specimen containing galena and chalcopyrite to see if it contains gold or silver. You would not assay it for lead and copper as you can tell it contains lead and copper just by looking at it. You might even be able to estimate how much too — at no cost to you. For example, a reference book states that galena contains 86.6 per cent lead and chalcopyrite contains 34.6 per cent copper. Suppose you estimate that your specimen contains about 10 per cent galena and 3 per cent chalcopyrite; it will therefore contain roughly 9 per cent lead and 1 per cent copper.

Moreover, for the gold and silver information from your specimen you do not need accurate assays — you basically want to know whether there is enough to justify more work. Assay laboratories usually offer just the thing for specimens — a **semiquantitative analysis** of a group of metals for a special price. This way you get the maximum information for the minimum cost. The amounts reported in a semiquantitative analysis are approximate and you should regard them as "ballpark" estimates. If you need accurate figures you will have to take the time and care to collect a proper sample and pay extra for the analysis.

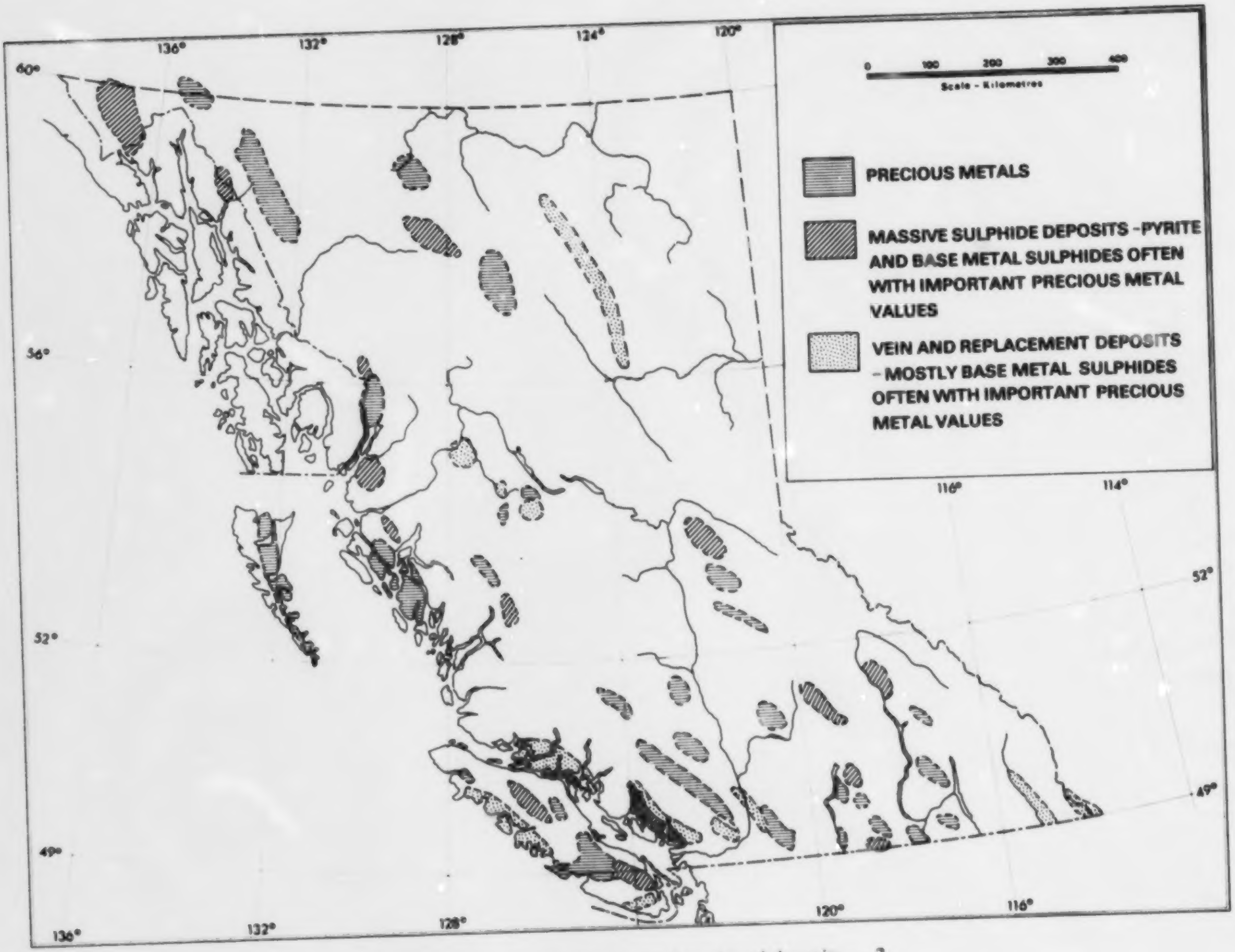
TYPES OF SAMPLES

Taking good samples requires time, patience, sometimes a lot of hard work, and always personal honesty. The types of samples most commonly taken are as follows:

(1) Grab Sample — This is just another term for a specimen or a number of specimens.

(2) Chip Sample — This is very difficult to take without a partner. The surface to be sampled should be carefully cleaned by hand or brush and it may need to be washed off to remove mud or loose material. Mark a straight line with stretched string, with chalk, or by eye across the surface. Your line should be at right angles to a vein, not along it, and should extend into any obviously mineralized wallrocks. For other mineralization the line should be across the width, not along the length.

Locate the line to pass through as representative a part of the surface as possible. You are not going to be able to fool a company geologist with lines passing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132°
128°
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116°
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300
400
Scale - Kilometres
PRECIOUS METALS
MASSIVE SULPHIDE DEPOSITS - PYRITE AND BASE METAL SULPHIDES OFTEN WITH IMPORTANT PRECIOUS METAL VALUES
VEIN AND REPLACEMENT DEPOSITS - MOSTLY BASE METAL SULPHIDES OFTEN WITH IMPORTANT PRECIOUS METAL VALUES

Figure 6-12. "Favourable areas" for mineral deposits — 2.

only through the good stuff, so why try to fool yourself? You then chip along the line with a pointed chisel and heavy hammer. Your partner shields the chisel point with a gloved hand or a piece of wood to prevent the chips flying and catches them in a tray or gold pan or on a clean sheet of canvas. Try to collect 1 to 2 kilograms of chips per metre of line, being careful not to take too much soft material and to get enough of the hard material. Record the length of the line sampled as well as particulars of sample location, sample number, and so on.

Geologists will often break up a line into several different samples, each representing different parts or types of the mineralization, as well as possibly sampling hangingwall and footwall rock or zones of alteration. They will do this to check variations in mineralization across the vein or for clues to the type of mineralization. Prospectors can seldom afford to do this sort of thing and if money is short it is far better to take several single samples of a vein at different places along its strike than several bits and pieces at just one or two locations.

(3) Channel Sample — The procedure for taking a channel sample is the same as for a chip sample, but instead of just chipping along a line, a channel a few centimetres wide and 1-2 centimetres deep is carefully cut out. This is the ideal sample to take from any surface, but in practice it is so difficult to do properly that it is seldom attempted. Hand-held diamond saws can be used to cut the channel, but this is obviously the sort of thing you should leave to a company.

(4) Chip-Channel Sample — This is a practical compromise between a chip sample and a channel sample. Instead of a chip sample along a single line, chips are taken from several lines spaced 5 to 10 centimetres apart.

(5) Bulk Sample — This is the kind of sample to take from broken rock, as from a trench or test pit which has been blasted or of gravels and sands when testing placer deposits. As the name suggests, it is a large

sample and might be the entire contents of a test pit, or every tenth shovel-full from a trench, etc. Unless they are taken for special tests or are from placer deposits, bulk samples should be reduced in size before sending them to an assay laboratory, otherwise you will pay to have them reduced by the laboratory as well as paying extra shipping costs.

REDUCING BULK SAMPLES

This can be done by hand but will take time and effort. If your samples are just a little overweight for the laboratory you might decide to pay the penalty rather than spend the time reducing them. However, for very large samples you will save money by reducing them yourself. The usual method is called **Coning and Quartering**. The sample is piled up carefully into a cone-shaped pile on a piece of ungalvanized sheet iron or sheet of plywood, and marked into four quarters (*see* Fig. 6-13). The quarters are then carefully separated with a shovel and opposite quarters are removed and set aside. The remaining two quarters are recombined into a new cone and the process repeated until the sample has been reduced to the desired size. The only catch to this is that you must break up large pieces to reduce the size of the rock or mineral fragments as you progress. Table 6-2 is a rough guide to the required sizes.

TABLE 6-2. LARGEST PARTICLES SIZES ALLOWED IN REDUCED SAMPLES

Weight of Sample Kilograms	Size of Largest Piece Centimetres
1 000	7.5
500	5.0
100	2.5
50	1.5
10	0.7
5	0.5
1	0.2

You can get by with pieces twice the above sizes but the accuracy of the assay results may be reduced.

Break up the oversized pieces with a hammer on a steel plate before each coning and quartering operation. Because of the work involved in reducing the samples properly, you would be wise to avoid bulk sampling.

TREATMENT OF ASSAY RESULTS

An assay result must be attached to some other quantity beside the concentration of assayed metal. For example, a chip sample is referred to the length of the chip line, ore grades are referred to the tonnage of ore, etc. The Additional Notes show how to calculate averages given several assays in a number of different situations.

THE NUGGET EFFECT

This term refers to problems created by the assay of samples for metals like gold which are very valuable, but occur as tiny particles scattered throughout large volumes of worthless rock. Suppose you send a 2-kilogram sample for a gold assay and it contains just one 2-milligram piece of gold — about the size of the head of a small pin. The actual concentration of gold in the sample is 1 gram per tonne or about 0.03 ounce per ton. But the laboratory does not assay the entire 2 kilograms of your sample — it would be far too costly; they crush the sample and then take a small sample of the powder for assay, actually about 29 grams. If that one speck of gold happens to be included in the assay, your result would be reported as 68.6 grams per tonne or 2 ounces per ton (you do not need to worry about how the calculation is made). If that speck of gold is not in the assay, your result would be reported as nil. Needless to say, your reaction to the assay results would be quite different in each case! This is an example of the "nugget effect" and unfortunately there is no low-cost solution to the problem. In extreme cases, companies have been forced to process bulk samples through a pilot mill to be certain of how much metal is actually there.

If a company suspects that assay results are high due to the nugget effect, it will reduce or **cut** the results to some arbitrary value before using them in any calculation of grades. For example, all gold assays exceeding 1 ounce per ton might be cut to 1 ounce per ton.

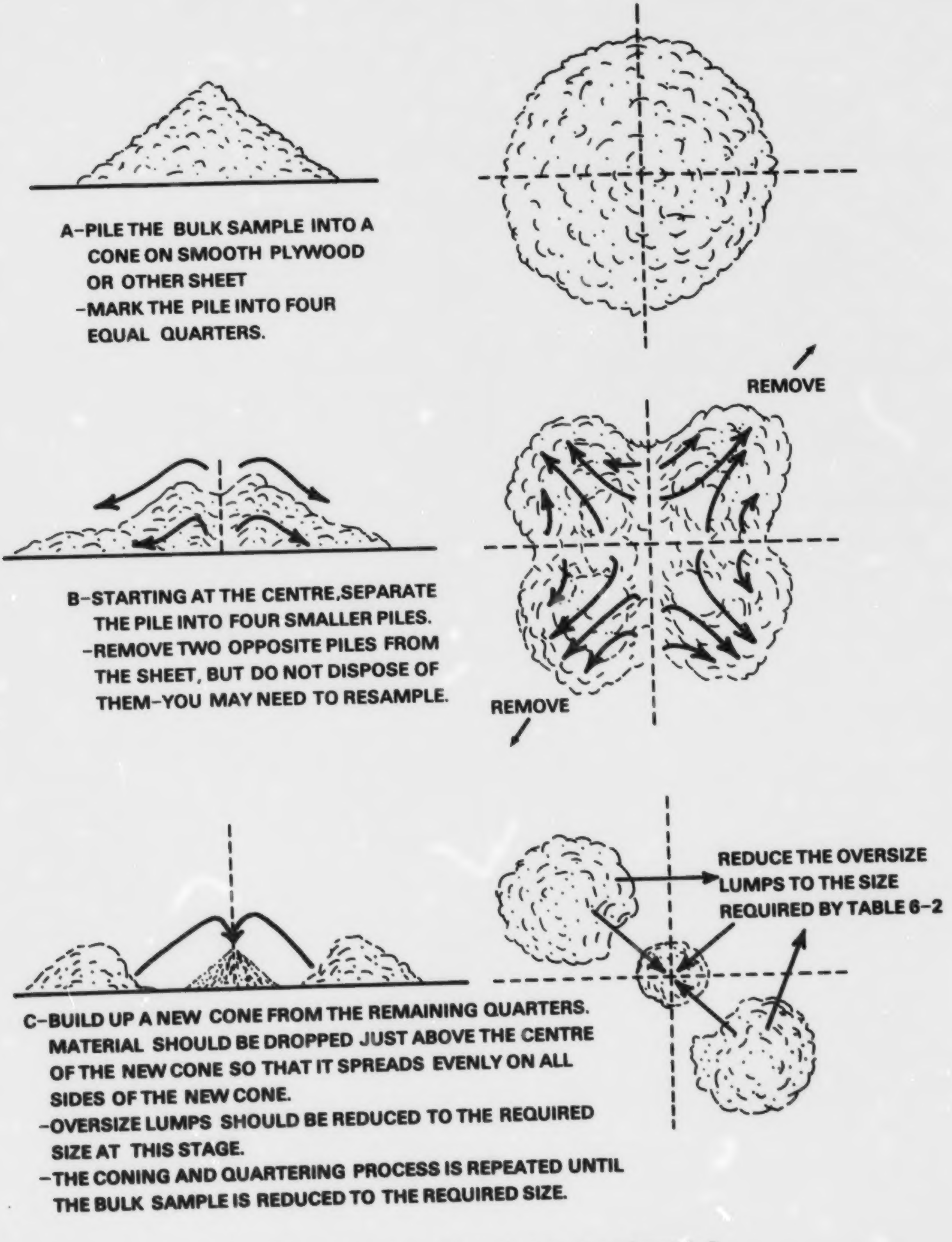
ASSAY LABORATORIES

Assay laboratories advertise in major mining trade publications and newspapers. They are also listed in the telephone directories of the larger cities. Your District Geologist will be able to tell you of those that have been in business for a long time or have established a good business reputation. He will also be able to advise you of the type of assay best suited to your needs. Write for price lists and examine the laboratory's charges and conditions carefully, especially the penalties applied for overweight samples, drying samples, and so on. Most laboratories will send you forms on which you can write out the assays you require and provide all the information needed by the laboratory. These forms also make it easy to add up the charges. Note that some laboratories do not ordinarily invoice individuals so their charges must be prepaid.

If you do not use the laboratory's own forms, at least make sure that all your samples are properly marked or identified and pack them securely to withstand shipment. You may know that the quartz vein sample came from one property and the sulphide sample from another, but without identifying numbers you will probably get two assay results and have to guess which property they apply to.

Make sure you indicate what assays you require and where to send the results. You would be surprised at just how often laboratories are left to guess what assays are required, who the prospector is, or where he or she lives!

Some mining companies will also do assays for the prospector, often at no charge. There may be limits to the number of samples you can send and most companies will only perform assays for certain metals. The company stands to benefit from this service, of course, for if anything exciting shows up in your results the company is the first to know and hopes to have the first chance at any deal! Check with your District Geologist for companies with good reputations and currently doing assays for prospectors. Unfortunately, an occasional dishonest company has been known to use this service to take advantage of the unsuspecting prospector.



A-PILE THE BULK SAMPLE INTO A CONE ON SMOOTH PLYWOOD OR OTHER SHEET
-MARK THE PILE INTO FOUR EQUAL QUARTERS.

B-STARTING AT THE CENTRE, SEPARATE THE PILE INTO FOUR SMALLER PILES.
-REMOVE TWO OPPOSITE PILES FROM THE SHEET, BUT DO NOT DISPOSE OF THEM-YOU MAY NEED TO RESAMPLE.

C-BUILD UP A NEW CONE FROM THE REMAINING QUARTERS. MATERIAL SHOULD BE DROPPED JUST ABOVE THE CENTRE OF THE NEW CONE SO THAT IT SPREADS EVENLY ON ALL SIDES OF THE NEW CONE.
-OVERSIZE LUMPS SHOULD BE REDUCED TO THE REQUIRED SIZE AT THIS STAGE.
-THE CONING AND QUARTERING PROCESS IS REPEATED UNTIL THE BULK SAMPLE IS REDUCED TO THE REQUIRED SIZE.

Figure 6-13. Reducing bulk samples by "coning and quartering".

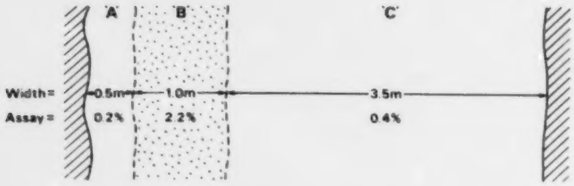
ADDITIONAL NOTES

ASSAY CALCULATIONS

An assay must be attached to some sample quantity such as width of a vein, length of mineralized drill core, tonnage of ore, and so on. To get an average assay from several similar assays — using assays of vein widths as an example:

(1) Multiply the assay × width.
(2) Add the totals from the above calculations.
(3) Divide the total from step 2 by the total of the widths.

Example No. 1 — A vein is subdivided into three sections and each section is assayed with the following results:

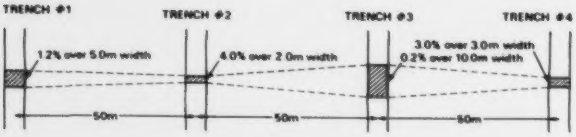


Calculation:

	Width		Assay		Width × Assay
"A"	0.5 m	×	0.2%	=	0.10
"B"	1.0 m	×	2.2%	=	2.20
"C"	3.5 m	×	0.4%	=	1.40
	5.0 m				3.70
	Total width				Total (width × assay)

Therefore average grade $= \dfrac{\text{total (width} \times \text{assay)}}{\text{total width}} = \dfrac{3.70}{5.0} =$ 0.74% over a total width of 5.0 m.

Example No. 2 — A vein is sampled in four trenches on strike with the following results:



Calculation:

(1) Average vein width =

$$\frac{\text{total vein width}}{\text{No. of trenches}} = \frac{20.0}{4} = 5.0 \text{ m}$$

(2) Average assay:

Trench	Width		Assay		Width × Assay
No. 1	5.0 m	×	1.2%	=	6.0
No. 2	2.0 m	×	4.0%	=	8.0
No. 3	10.0 m	×	0.2%	=	2.0
No. 4	3.0 m	×	3.0%	=	9.0
	20.0 m				25.0
	Total vein width				Total (width × assay)

Average assay $= \dfrac{\text{total (width} \times \text{assay)}}{\text{total vein width}} = \dfrac{25.0}{20.0} =$ 1.25% over an average vein width of 5.0 m and a vein length of 150 m.

Note: **This calculation works only if the trenches are evenly spaced.**

If the trenches are *not* evenly spaced, the calculation becomes tricky. Try to keep trenches evenly spaced!

Example No. 3 — A mine has three ore bodies grading as follows:

No. 1 — 200 000 tonnes containing 2.4% copper and 0.0 g/t gold.
No. 2 — 1 000 000 tonnes containing 1.2% copper and 1.5 g/t gold.
No. 3 — 55 000 tonnes containing 4.6% copper and 2.5 g/t gold.

Calculation (copper grade):

	Tonnes		Grade		Tonnes × Grade
No. 1	200 000 t	×	2.4%	=	480 000
No. 2	1 000 000 t	×	1.2%	=	1 200 000
No. 3	55 000 t	×	4.6%	=	253 000
	1 255 000				1 933 000
	Total tonnes				Total (tonnes × grade)

Therefore average copper grade =

$$\frac{\text{total (tonnes} \times \text{grade)}}{\text{total tonnes}} = \frac{1\,933\,000}{1\,255\,000} = 1.54\%$$

Calculation (gold grade):

	Tonnes		Grade		Tonnes × Grade
No. 1	200 000 t	×	0.0 g/t	=	0
No. 2	1 000 000 t	×	1.5 g/t	=	1 500 000
No. 3	55 000 t	×	2.5 g/t	=	137 500
	1 255 000				1 637 500
	Total tonnes				Total (tonnes × grade)

Therefore average gold grade =

$$\frac{\text{total (tonnes} \times \text{grade)}}{\text{total tonnes}} = \frac{1\,637\,500}{1\,255\,000} = 1.3 \text{ g/t}$$

The mine has 1 225 000 tonnes averaging 1.54% copper and 1.3 g/t gold.

Note how the zero gold grade is treated — it cannot be ignored in the average!

For examples of assay calculations for placer deposits, *see* Chapter 11.

CHAPTER 7 — MINING

INTRODUCTION

A large number of complex factors go into a decision to mine. A prospector does not need to understand the technical details, but he or she should have some general knowledge in order to appreciate how a mining or exploration company thinks and how it might view that property of yours that you are so excited about.

This chapter will describe these factors in varying detail, depending on their importance to the prospector. An exploration geologist will not worry about any one of them in detail to start with, unless it has a particularly adverse effect on the value of your property. His immediate concern is to see whether he thinks your property is worth exploring and then if a deal is signed, he wants to see if he can turn your property into a mine. If the results of initial exploration are good, the geologist will then look ahead and think about such things as the cost of getting a road or power into the property and consider that salmon stream that crosses the best mineralization.

FROM PROSPECT TO MINE

The following steps are usually taken to convert a raw prospect to a mine. They overlap to some extent and two or three may be in progress at any given time.

PROSPECTING

This is the first stage and, to some extent, it is your responsibility. I know of no study that confirms this, but it is often stated that out of every 1 000 prospects only one will become a mine. Whether this figure is true or not, do not be discouraged. Because every prospect must be tested to see if it is any good, mining and exploration companies spend millions every year on properties that will never become mines, so you should try to get your share!

EXPLORATION

This usually starts in a small way, often with detailed geological mapping, and some geochemistry and geophysics. If results are encouraging, then more funds are spent on trenching or test pitting and drilling **targets**. If drilling intersects mineralization and the assay results are good, then **step-out** drilling is done to see how far the mineralization extends and to test it at depth. If results are still favourable, then **fill-in** drilling between earlier drill holes is done to get details of the size, shape, grade, and tonnage of the deposit, so that **ore reserve** calculations may be made. Sometimes underground exploration may be necessary to get additional information or to get bulk samples.

FEASIBILITY STUDY

This is a detailed study to determine if a property can be mined at a profit and the best way to mine it. Many factors will be considered in detail in the study, including the size of the operation and its life expectancy, the best mining method, the best way to process the ore, what product to produce, where to sell the product and the likely selling price, the source of power, supplies and labour force, waste disposal and environmental problems, and the cost of the project and how to provide the needed finances.

DECISION TO MINE

If the outcome of the feasibility study is favourable, then a decision to go into production will be made.

DETAILED DESIGN STAGE

At this stage, plans are drawn up and final details of the operation are worked out.

PERMITTING STAGE

This usually occurs at the same time as the detailed design stage, because various government agencies must review and approve detailed plans before necessary permits can be granted. Almost all projects will require an environmental impact study, and very large projects may require public hearings before final permission to mine is granted. It is worth noting that environmental requirements of a large new mining operation currently account for about 20 per cent of the total capital cost and about 2 years of the total time that elapses from prospect to mine stages.

DEVELOPMENT

This stage involves the preparation of the property for mining and the construction of the mine plant.

MINING

Production is the object of the process. It is small wonder that it may take 10 years or more from discovery of the prospect to the opening of the mine. As will be seen later, mines are usually surface — **open-pit** -or **underground** operations. Both types, however, share the same basic operations, which are listed below:

(1) **Drilling** and **blasting** of ore, gangue, and, if necessary, waste rock.

(2) **Loading** and **hauling** (or hoisting) ore to the **mill** for processing, or waste rock to a dump.

(3) **Crushing** — the reduction of the ore to gravel size.

(4) **Grinding** — the reduction of the crushed ore to a fine powder.

(5) Separation of the desired minerals — usually as a **concentrate**.

(6) Disposal of the rock residue — **tailings** — to a **tailings pond**.

(7) Shipment of the product to a market.

RECLAMATION

When a mine runs out of ore and closes, buildings and equipment must be removed and the minesite and workings reclaimed to make them safe or inaccessible, and environmentally stable.

REQUIREMENTS FOR A MINE

It is also desirable to look at mining operations from a different perspective and to consider the basic requirements of a mining venture, especially as they concern the prospector.

ORE

Clearly a mine needs ore. Ore was defined earlier as a "rock worth mining" — meaning mined at a profit. In practice, "ore" can be described in a variety of terms which may be confusing. The most commonly used terms are explained following:

Proved Ore — The mineralization has been thoroughly explored and sampled so that the size, shape, grade, and tonnage are known accurately. Any likely error in the calculations is small and will not affect the mining operation.

Probable Ore — The mineralization has been extensively explored. The size, shape, grade, and tonnage are reasonably well known, but some room for error exists.

Possible Ore — The mineralization is known to exist and is believed to be of "ore" grade. Some general idea of the size, shape, grade, and tonnage will be known from limited exploration, but considerable room for error exists.

Potential or Inferred Ore — The mineralization is believed to exist on the basis of some geological information, but the size, shape, grade, and tonnage are a matter of speculation.

Drill-indicated Ore — This term is often used in a manner which implies that the ore is proved or probable. In fact it can be any ore category, based on drilling information.

Marginal Ore — Marginal ore can be any of the above categories, but the profitability is currently in doubt. This could be for a variety of reasons, such as low grade or metal prices, high cost of mining, or excessive **dilution**. Dilution results from the mixing in of unwanted gangue or waste rock with the ore during mining.

Ore-grade Mineralization — This term should sound a warning bell; it suggests there is a problem somewhere. It might mean that the mineralization would be ore if there were more of it, or if the veins were only wider, of if it could be mined without dilution, or if some other problem could be solved.

A mining operation is based on the proved ore reserves and sometimes on the proved plus probable reserves. As mining progresses, money is spent to explore and upgrade probable ore to proved, possible ore to probable, and so on. It would be too expensive, and it is not necessary, for a mining company to make sure all its ore is "proved" before it starts mining; it just needs enough proved ore to ensure that the mine will be profitable.

ACCESSIBILITY

Mineralization, by its nature, is seldom located conveniently near a major urban centre. The accessibility of a property has a major effect on the cost of prospecting, exploration, and mining. For the prospector a readily accessible area will cost less to prospect, and less time and money spent on travel means that more can be spent on prospecting. However, such areas are likely to have been well prospected already. Much of the more promising ground may already be staked and your chances of finding something that everyone else has missed will be much smaller. The exact opposite can, of course, be said for areas that are difficult to get into. The mining company, on the other hand, must always consider possible mining costs, and remoteness may be more of a problem than accessibility. For example, a property 20 kilometres from a large town, that can only be conveniently reached by helicopter, although expensive to explore, might be very attractive from a mining point of view. Remoteness is a compound problem in that remoteness from a road, say, usually means remoteness from power lines, sources of labour, supply centres, and so on.

For prospector and mining company alike, it means that *the quality of any prospect in remote or poorly accessible areas must be very much better than those in areas that are readily accessible*.

For similar reasons, mineralization at high elevations and in very rugged terrain must be of better grade or extent to interest a mining company due to the increased cost of access and problems caused by the severity of weather at high elevations.

METHODS OF MINING

As indicated earlier, a mine is usually either an open-pit or an underground operation. Some deposits may be mined by a combination of open-pit and underground methods. It is important for a prospector to be able to determine if his property is a potential open-pit property or underground property. The reason is cost; it is much easier and cheaper to mine from the surface than from underground. At the time of writing (1985), typical costs range from $5.00 to $50.00 per tonne to mine ore (and waste) from an open pit, compared to $50.00 to $400.00 per tonne for an underground mine. It follows then that if operating costs for an underground mine are 8 to 10 times higher than for an open pit, then *the grade of ore must also be 8 to 10 times higher*.

Open-pit deposits must be at or very close to the surface and with the exception of the occasional small high-grade deposit they should be very large so that the economies of large-scale operation can be effected. An open-pit mine typically produces 10 000 to 100 000 tonnes per day of ore and often comparable amounts of waste rock (Fig. 7-1). The

Figure 7-1. Open pit mine.

grade of ore is usually low to very low, and the mineralization is disseminated or more or less uniformly spread throughout very large volumes of rock. The ratio of waste removed to ore processed is called the **strip ratio** and obviously the lower the ratio the better.

An underground mine may produce anywhere from a few tonnes per day to a few thousand tonnes per day. The ore is usually confined to comparatively narrow veins, beds, or shear zones, but may extend to considerable depth. As indicated, ore grades must be much higher than in a typical open pit, but the amount of ore is far less.

Some tips on deciding whether a prospect is an open-pit or an underground possibility are given in Chapter 8.

There are a number of terms used to describe the workings of a typical open-pit or underground mine that the prospector should be familiar with. These are best explained by means of Figures 7-2 and 7-3.

SPACE

Prospectors commonly stake too little ground, especially in difficult or rugged terrain. While it is natural to keep costs down and unintelligent to stake everything in sight, prospectors often fail to allow for possible extensions to their mineralization, especially for an open-pit possibility and forget that a mine will need space for buildings, plant, and so on. Further, these may have to be located away from the mineralization, particularly in the case of an open-pit mine. The prospector should not be concerned with such details as plant layout, but depending on the situation he or she should give some thought to this at the time of staking. It will clearly not help you to get a deal on that mountain property, for example, if the only possible place for buildings or a tailings pond is right next to your claim and it ends up being staked by someone else.

PROCESSING THE ORE

Beginning prospectors, especially, tend to look up the current market price for the metals in their samples and figure the value of their mineralization at 100 per cent of the assay results. Mining costs have been mentioned previously, but processing, smelting, and refining all cost money too, and a better starting figure might be 80 per cent of assay results. This will naturally vary depending on the particular ore. The fact is that no metallurgical process is 100 per cent efficient and current technology for treating certain ores, for treating some concentrates, and for refining some impure metals leaves a lot to be desired. Again, a prospector does not need to have expert knowledge of mineral processing, but here are a few points to watch for.

Problem Ores — Complex mixtures of several sulphides are usually difficult to treat, especially if they are fine grained and very thoroughly mixed. Even comparatively common

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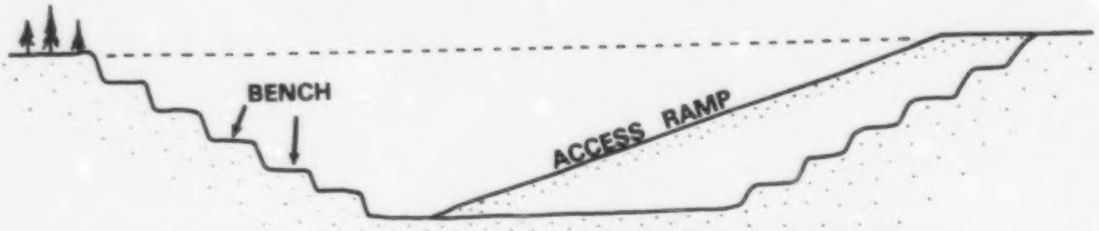


- HEIGHT OF BENCHES IS COMMONLY 10–20 METRES, DEPENDING ON THE DRILLING AND LOADING EQUIPMENT USED.
- BENCHES ARE DRILLED AND BLASTED, AND THE ORE (OR WASTE) LOADED BY SHOVELS OR FRONT LOADERS INTO TRUCKS FOR TRANSPORT TO THE MILL (OR WASTE DUMP)

Figure 7-2. Cross section of an open pit.

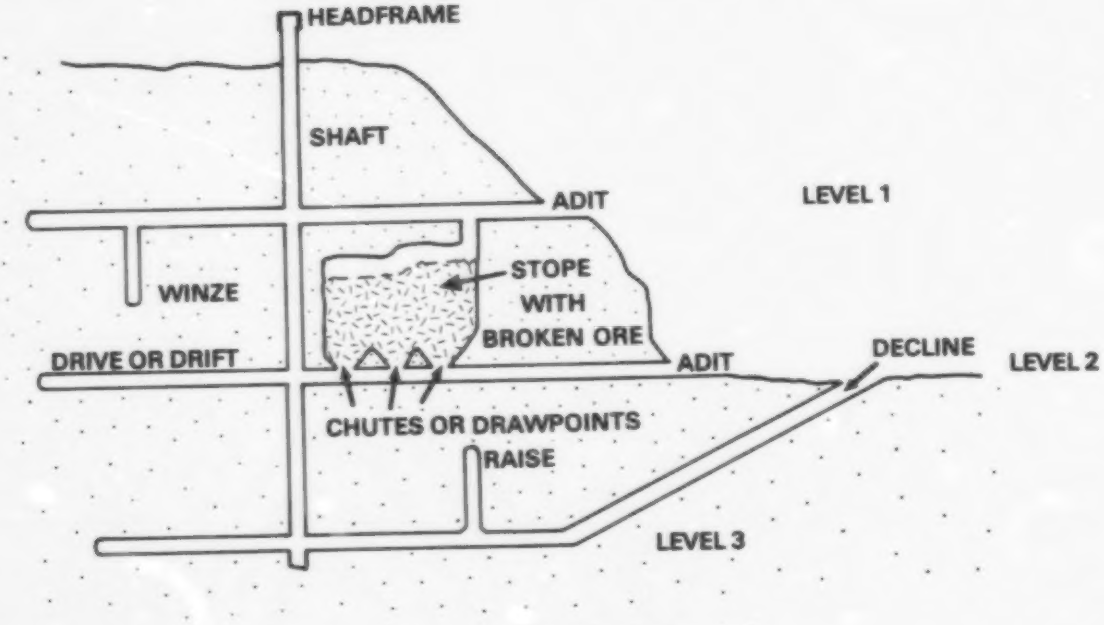


Figure 7-3a. Cross section of an underground mine.

mixtures such as copper, lead, and zinc sulphides are difficult to separate completely and impure concentrates draw a **penalty** (meaning that extra charges are made) at most smelters.

Arsenic and Antimony Sulphides — Precious metals contained in arsenic sulphide ores, and especially in antimony sulphide ores, are difficult to process. The byproduct arsenic and antimony compounds are often difficult to sell or environmentally hazardous to dispose of. Base metal sulphide ores containing small amounts of arsenic or antimony may in fact not be economic, due to excessive penalties or rejection by the smelter.

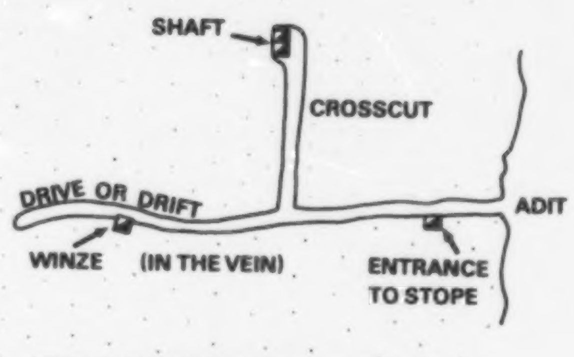
Recovery and Grade — Generally, the lower the grade of the ore, the poorer the recovery. For example, it might be possible to recover 95 per cent or more of the gold from an ore assaying 10.0 grams per tonne, but only around 60 per cent from an ore assaying 1.0 gram per tonne. Moreover, the processing costs *per gram of gold recovered* will also be considerably higher — in this example, about 16 times higher.

MARKETING THE PRODUCT

Anyone who can predict metal and mineral prices in these uncertain times does not need to go prospecting for a living. Making any kind of statement about the likely trend of any particular metal or mineral is a very risky proposition.

Most large metal mines will try to sell their concentrates on long-term contracts. The price is often determined by a complicated formula and may be above or below the current world price at any given time. Non-contract sales are at the mercy of the current market situation. Ready markets exist for the precious metals and most base metals. However, the fact that there is a "spot" or market price for the less-common metals or minerals does not mean that anyone is necessarily buying or selling at that price. It is currently very common practice to sell some metals and industrial minerals at a discount from the spot price. Remember too, that spot prices are usually for a refined product and not for mine concentrates or unrefined metals.

Current prices for precious metals are readily available from the media and most banks and financial institutions. The financial papers, stock brokers, major national and most provincial newspapers, and more specialized newspapers, such as the *Northern Miner*, will have price information on the more common metals. Prices for less common metals and industrial minerals are available in certain trade publications and specialist journals, which may be difficult to locate outside major cities. They include such publications as the *Metals Week*, the *Mining Journal*, and the *Engineering and Mining Journal*. Specialist publications will often carry articles about price trends and future market predictions as well. Your District Geologist will also have or be able to find out the current price of any metal or industrial mineral you are likely to be interested in.



LEVEL 1 SHOWN. IN PRACTICE THERE WOULD BE PLANS FOR EVERY LEVEL

Figure 7-3b. Plan of an underground mine.

CHAPTER 8 — FIELDWORK

INTRODUCTION

This chapter covers the use of maps, air photographs, and compasses; the search for mineralization and what to do when you find it. Many of the details of map and compass work can be explained much more easily in a practical or "laboratory" session with an instructor than is possible in a written text and I urge you to take advantage of such instruction if at all possible. For those who cannot obtain practical instruction some Additional Notes have been included, but if you still have questions about the use of maps or compasses, you are urged to contact your District Geologist or some other knowledgeable person. The bush is no place to have to work out your difficulties.

Other fieldwork subjects such as clothing, footwear, camp gear, cooking, first aid, and so on will not be covered. My experience is that the great majority of people who become interested in prospecting already have some outdoor experience, either through their work or their leisure-time activities. Moreover, information on these subjects is generally readily available from other prospectors, reputable outdoor suppliers, and books. You may already be familiar with the use of maps and compasses, so you may be able to skip over the next few sections.

MAPS

Everyone has used a map at some time or another. The kind that is most useful to prospectors is called a **topographic** or **topo map**. Topo maps serve as the base or starting point for most other kinds of maps, including claim maps and geological maps. A topo map depicts the topography or physical features of the map-area by means of contour lines and symbols. The key features of a topographic map are described below.

NORTH POINTS

A topo map usually has three "norths" on it, depicted in one of the margins. By convention, the sides of the map are **true** or **geographic north** lines, with north at the top. You will also see the direction of **magnetic north**, which is the direction that a magnetic compass points. The angle between true north and magnetic north is called the **declination** and, in British Columbia, magnetic north is always to the east side of true north. Note that *the declination varies from place to place*, so if you go into a new area be sure you know what the new declination is. Note too, that *the declination changes slowly with time*. If you have to use an old topo map, the change may be significant and you should do the simple calculation to check the current declination. For example, a map of the Horsefly, British Columbia, area published in 1954 states that the declination is 25 degrees 16 minutes east and the annual change is 4 minutes westerly. This means it is decreasing and in the 31 years from 1954 to 1985 it will have decreased 124 minutes or close to 2 degrees (60 minutes = 1 degree). So the declination in 1985 would be about 23 degrees 12 minutes east — call it 23.25 degrees or, for most compasses, 23 degrees would do.

The **grid north** applies to the pattern of blue or brown squares which you will see on a topo map. This is part of the **Universal Transverse Mercator Grid** or **UTM Grid** and is very useful, because the squares are 1 kilometre or some multiple on the side. The grid lines are numbered and with them points on the map can be located quite accurately, and far more easily than by means of latitude and longitude. A box in the margin of every topo map tells you how to do this.

SCALE

The scale of a map tells you how the distances that you measure on the map correspond to distance on the ground. There are many ways of showing a scale. The two most commonly used are illustrated on Figure 8-1, taken from an older map, Horsefly, and a modern or so-called "metric" map, Carrier Lake. The scale for the Horsefly map is given as "1:63,630 or 1 inch = 1 mile". It means that one inch on the map represents 63,360 inches on the ground, or exactly 1 mile. The other scales are probably more familiar and are called **bar scales**. The Carrier Lake map scale is just given as "1:50 000". It means that 1 unit on the map (your choice!) equals 50 000 units on the ground. Thus 1 centimetre would equal 50 000 centimetres or 500 metres on the ground. You could use centimetres with the Horsefly map and inches with the Carrier Lake map, but neither would be too convenient. The so-called metric maps, with scales like 1:50 000, 1:100 000, 1:250 000, are clearly designed to use the advantages of the metric system and there are now very few of the old-style maps left in print.

The scale of the map has a critical effect on the amount of detail that can be printed by means of contours or symbols. There is always a trade-off between the area covered by a map and the amount of detail depicted. A **small-scale** map such as 1:250 000 will only give a small amount of detail but it will cover a large area. A **large-scale** map such as 1:50 000 or 1:10 000 will give a larger amount of detail, but for a much smaller area.

MAP SYMBOLS

In order to represent features on a map some kind of symbol must be used. A **key** or **legend** giving the most important symbols appears at the side of most topo maps. The complete list of symbols used on Canadian topo maps is sometimes printed on the back of the map. If you find one it is worth spending some time to familiarize yourself with the symbols, especially those used to depict topographic features.

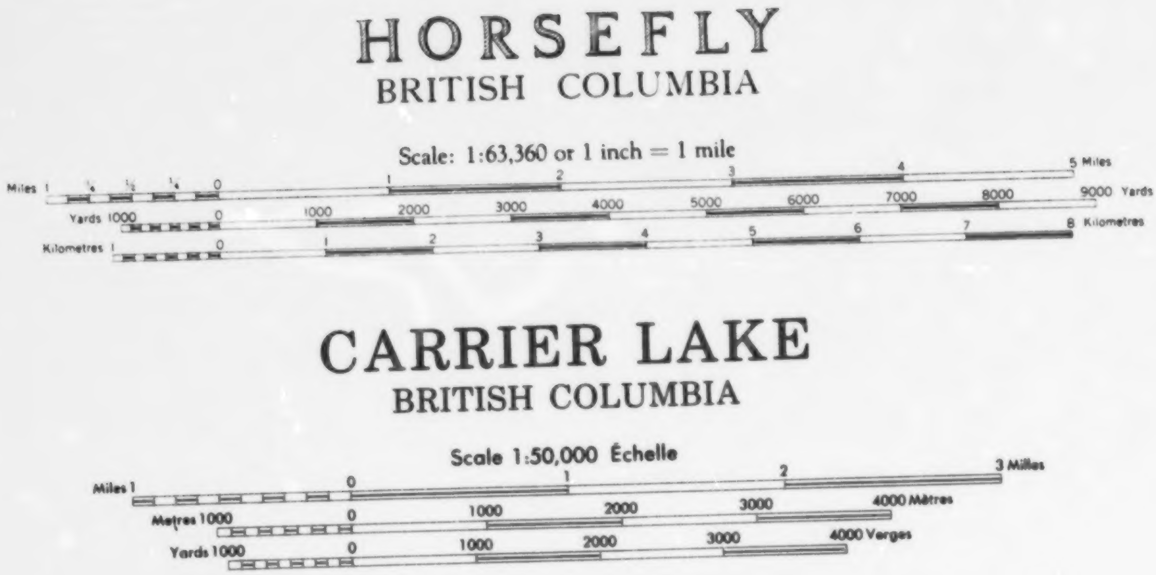


Figure 8-1. Map scales.

CONTOURS

Contours are the most important feature of a topographic map — with practice they will give you a very good idea of what the ground actually looks like. Unfortunately people seem to fit into two categories — those who have little difficulty understanding contours and those who have a lot of difficulty understanding contours. If you think you fit into the second category, take heart! There are only a few key points that you really need to know.

To begin with, a contour line on a map means that the ground anywhere along that line is the same height above sea level. The 1,000-foot contour line, for example, shows where the ground is exactly 1,000 feet above sea level. Another way of looking at this example would be to imagine the sea rising 1,000 feet. It would, of course, flood the land and the new shoreline would be exactly along the 1,000-foot contour.

Not all contours on a map are labelled. Usually you have to count up or down from a nearby labelled one. To do this you need to know the **contour interval**; it is marked at the bottom of the map or in the legend. For example, if a map states that the contour interval is 100 feet, then contours will be drawn on the map for every 100-foot increase in height above sea level — 100, 200, 300, 400 feet, and so on.

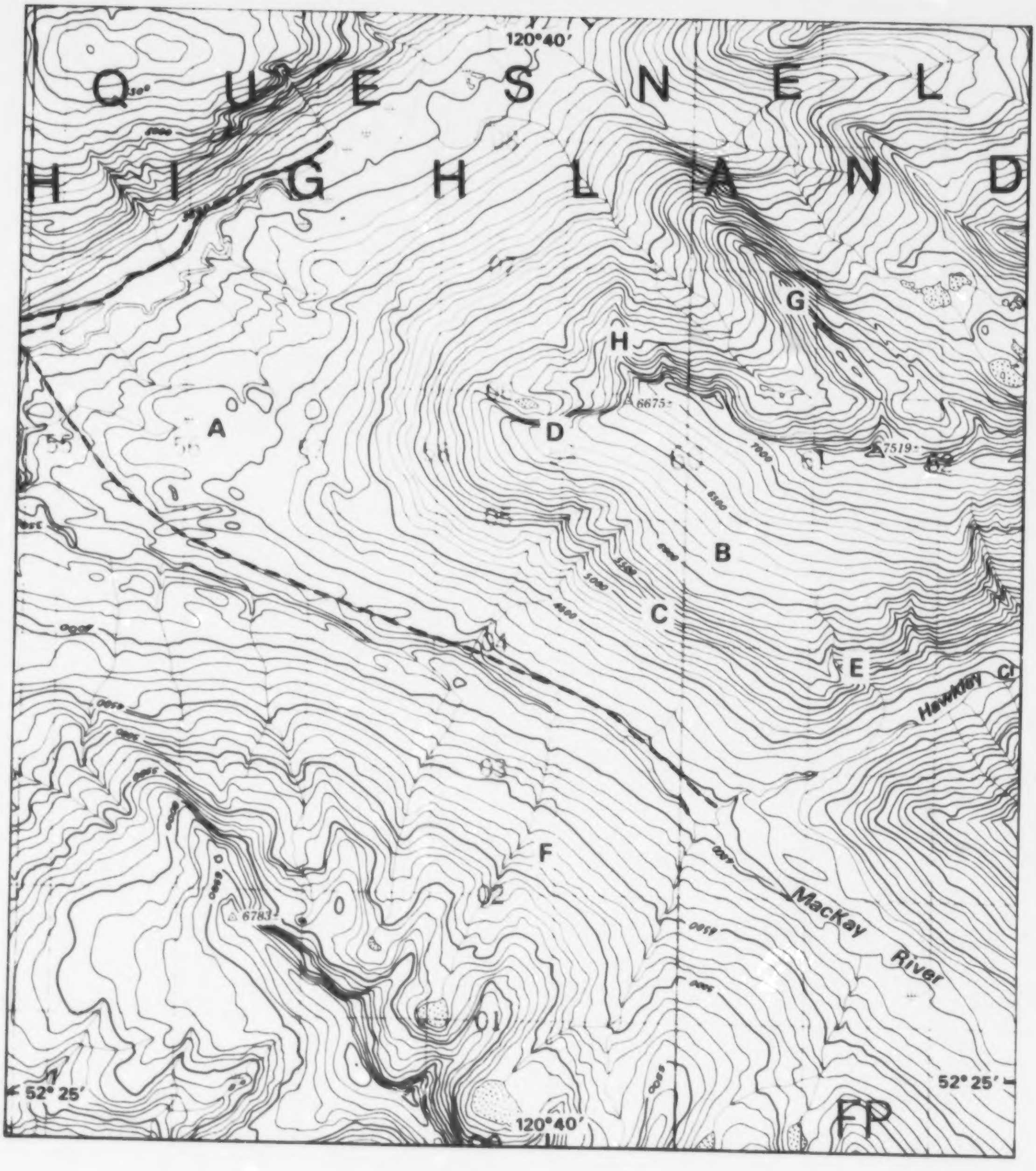
One point you must watch for is that all new editions of topo maps have contours expressed in metres instead of feet. Contour intervals such as 50 feet and 100 feet are being replaced by 10 metres and 20 metres and, of course, all marked heights will be in metres. There is a world of difference between a 2,000-foot hill and a 2 000-metre "hill"! It is confusing having to deal with both kinds of topo maps. Unfortunately we will just have to accept the situation, as it will take several years to publish new editions of all of Canada's topo maps.

There are some important points about contours that will help you to visualize what the ground is doing and to plan your fieldwork. They can be more readily understood by reference to Figure 8-2 which is part of the MacKay River, British Columbia, area. The scale is 1:50 000 or 1 centimetre = 500 metres and the contour interval is 100 feet.

(1) The closer together the contours are the steeper the ground is. The ground at point "A", for example, is quite flat; in fact you may see the symbol for a marsh on the area. At "B" the contours are closer and by measurement, knowing the scale of the map, the ground rises 1,000 feet in 1 kilometre, or about 1 in 3 which is quite a steep slope. At "C" the slope is steeper still, about 1 in 1.5, a "hands-on" slope for most people. At "D" the contours are all crowded on top of each other, which means a cliff.

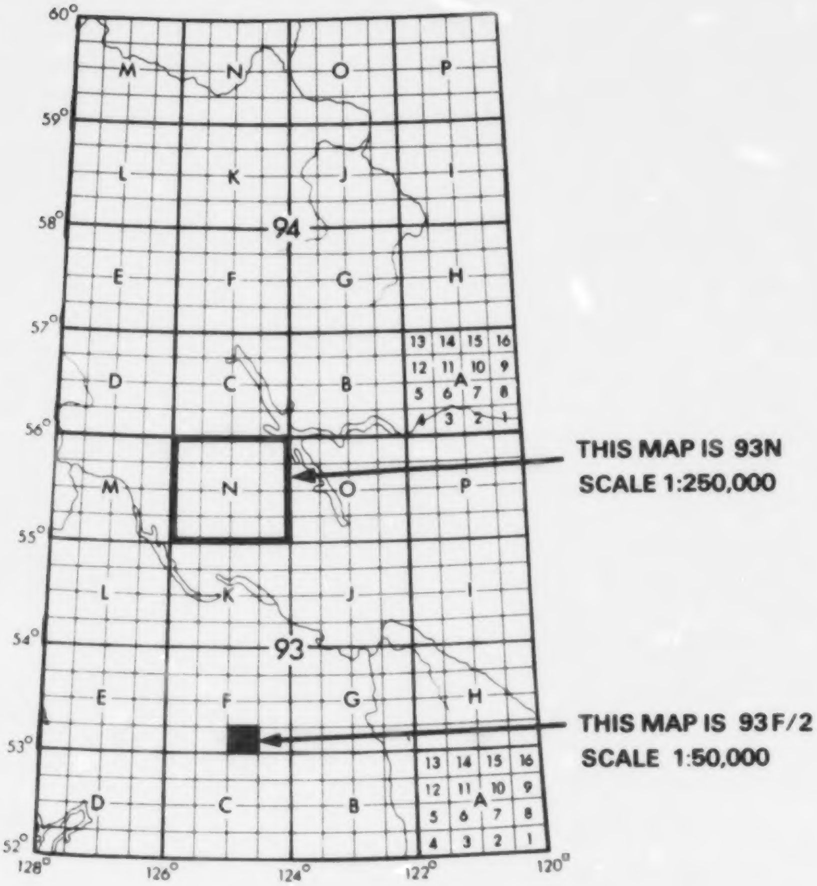
(2) Contours form a "V" when they cross a stream and the "V" points upstream. Examples of this are shown at "E" and "F".

(3) Contours form a "V" when they cross a ridge and the "V" points down the ridge. Examples of this are shown at "G" and "H". You may find it easier to understand these last two points if you imagine what a level road along a hillside must do when it crosses a valley and a ridge respectively.



SCALE 1:50,000

Figure 8-2. Part of the MacKay River, B.C. map sheet 93A/7.



THIS MAP IS 93N
SCALE 1:250,000

THIS MAP IS 93F/2
SCALE 1:50,000

Figure 8-3. Part of the National Topographic System (NTS) for identifying maps.

THE NATIONAL TOPOGRAPHIC SYSTEM (NTS)

This system specifies the location of any map-area in Canada by means of a number and letter combination. The scales of published maps are also closely related to the system so that a single NTS reference will tell you where the map-area is and also the map scale to expect. Figure 8-3 shows part of the system.

Basically Canada is divided into a number of "rectangles" along latitude and longitude lines. These are numbered so that the "tens" part of the number increases from east to west and the "units" part of the number increases from south to north. British Columbia is thus covered by "rectangles" 82, 83, 92, 93, 94, 102, 103, 104, and 114. Maps in this sequence are published at a scale of 1:1 000 000.

Each "rectangle" is then subdivided into sixteen smaller "rectangles", each given a letter: 93A, 93B, 93C, and so on. Note the strange way this is done; the reasons for this are largely historical. Maps in this sequence are published at a scale of 1:250 000 and are very useful for reconnaissance or planning purposes.

Each of these smaller "rectangles" is further subdivided into sixteen still smaller "rectangles" which are given a second number: 93A/1, 93A/2, 93A/3, and so on. The second numbers follow the same order as the letters. Maps in this sequence are published at a scale of 1:50 000 and are useful for more detailed prospecting and plotting claims.

Some modifications are made for map scales such as 1:100 000 or 1:500 000 and the basic number-letter scheme changes for points in the far north of Canada, but once you understand the idea of the system it is easy to follow the few modifications.

All topo maps have a geographic name as well as an NTS designation. You may need both when you order or buy maps.

AIR PHOTOGRAPHS

Air photographs, as the name suggests, are photographs of the ground taken from specially equipped aircraft. They are very valuable for prospecting and with the right setup you can see a three-dimensional image of the ground. They are available in a variety of scales and vary in age and quality. Typically they are in black and white, but for some areas colour photographs are available. Colour photographs are very expensive, however.

Reference maps are available from the Ministry of Environment for each scale of photograph published. They show the aircraft **flight lines** and **photograph number** on them. Thus BC1703-16 would mean a British Columbia Government photograph, flight line number 1703, and photograph number 16. There is a 2/3 overlap between each photograph and the next one on the same flight line and a 1/3 overlap between photographs on neighbouring flight lines. Thus any point on the ground will appear on at least two photographs and possibly on as many as six.

The great value of air photographs arises because any ground in the area of overlap of two photographs can be viewed in three-dimensional relief by viewing one photograph with the left eye and the other with the right eye, preferably with the aid of a device called a **stereoscope**. You do not see a true-to-life image, but one having **vertical exaggeration**. Hills appear several times higher and slopes much steeper than in reality. This makes it much easier to spot outcrop areas and other details of the topography that could not possibly be depicted with contours on a topo map.

COMPARISON OF MAPS AND AIR PHOTOGRAPHS

Both have their advantages and disadvantages. Maps are cheaper and they have exact geographic, grid, and magnetic north information. They are printed to an exact scale and have exact contours and elevations. The cultural information may also be of value. The disadvantage of topo maps is that the topography must be interpreted from contour information. This can only be done in a very general way and such features as likely outcrop areas can seldom be determined from contours.

Air photographs, on the other hand, are more expensive and it is generally too costly to purchase coverage for large areas. The best collections of air photographs are to be found in Regional and District Forest Service offices where members of the general public usually can arrange to see coverage of areas of interest. Usable copies of air photographs can often be made at such offices on a good photocopying machine for a small charge.

If you are interested in a small area it may well be worthwhile to purchase air photograph coverage. If visibility is not restricted by trees or weather, with the aid of a large-scale photograph and practice, you can usually see exactly where you are on the ground. Geologists and some prospectors often do their mapping directly on air photographs, usually with numbered points on the photographs and notes for each point in their field books.

Cost is not the only drawback to air photographs. For technical reasons, the scales are not exact and very few air photographs are available in metric scales. North may be any direction on the photo; it depends on the flight line direction. Thus, you must compare an air photo with a topo map of the same area to determine the exact direction of true north and the actual scale.

Another drawback to the use of air photographs is that it may be difficult to use the three-dimensional potential of air photographs in the field. Stereoscopes that can handle full-sized air photographs are very expensive and unsuitable for field use. Small folding stereoscopes are available for a few dollars but they limit you to an area of overlap no wider than the distance between your eyes, about 7 centimetres, so you may have to bend or fold your photographs to view the area you are interested in.

COMPASSES

There are some people who boast that they have never carried a compass and they can find their way around in the bush as well as anyone. It is no surprise to anyone knowledgeable about the bush that search and rescue efforts are commonly needed to find these people. Even if you think you know exactly where you are in the bush at all times, there is no way you can measure the strike of a vein or fault, cut a claim line, or give directions to find mineralization to ordinary mortals, such as company geologists, without a compass.

The features of a good compass follow. The first three should be considered essential; the others are highly desirable.

(1) It must have some means of adjusting for the magnetic declination so that all directions can be related to true north.

(2) It must have some means of "damping" or slowing down the swings and vibrations of the compass needle. This is usually done by "magnetic damping" or immersing the needle in a liquid-filled capsule.

(3) It must have some means of aiming the compass at a target while being able to see the compass needle. This is commonly done by a mirror arrangement.

(4) It should have some means of measuring dips. If this takes the form of a simple pendulum device within the compass capsule it adds very little extra to the cost.

(5) It should be graduated in 360 degrees. Compasses graduated in four "quadrants" of 90 degrees are archaic and confusing to use.

There are many makes and models of compasses available but two types currently outnumber all others in use by prospectors and geologists. They are the "Brunton" and its many imitators and the professional model "Silva" compasses (Fig. 8-4). The Brunton and its copies are much more elaborate in design and potentially more accurate. Despite their high price they seem to enjoy a popularity that is, frankly, hard to justify by their ease of use. The commonly used Silva compasses, as well as being less expensive, have such features as built-in scales and a transparent base, so that they can be used to measure distances and directions directly on a map. They are also easier to use in poor light or if you get caught out at night. In very cold weather, however, the compass and dip needles may become very sluggish in their liquid-filled capsule, unless the compass is kept in an inside pocket between readings.

If you buy a compass, whatever the make or model, *read and understand the directions that come with it*! At least one manufacturer provides a detailed and comprehensive set of instructions on the general use of compasses. Some Additional Notes on the use of a compass are provided at the end of this chapter. Figures 8-5 and 8-6 show a compass being used to measure strike and dip.

Treat compasses with care. Keep magnetic metals, especially your hammer, away from your compass when you are using it, and *keep your magnet away from it at all times*.

GEOLOGICAL MAPS

Geological maps come in two principal kinds — surficial and bedrock. Surficial maps show the types of soils and overburden to be found in an area and are generally of much less use to a prospector than a bedrock geological map. A bedrock map attempts to show the types of rocks found in the map-area, as well as the structure and age of these rocks.

Most of the geological maps of the province have been prepared by the Geological Survey of Canada at a scale of 1 inch = 4 miles or 1:250 000. Such maps are really "reconnaissance" maps, and certainly not detailed outcrop maps.

Some large-scale geological mapping of selected areas is done by the federal government, but this is mostly a provincial responsibility. In British Columbia detailed mapping is available for selected areas such as mining camps, "hot" exploration areas, and individual properties. Mining and exploration companies commonly map claim areas in detail and copies of the maps are available in **Assessment Reports**. These are available to the public when the period of confidentiality, usually 1 year, has expired. Universities, too, do geological mapping as part of research and thesis projects.

An *Index to Bedrock Geological Mapping* is available for the province. Your District Geologist will have a copy of this, as well as copies of most of the available maps for his district.

A problem which prospectors often have with geological maps is that the rocks are grouped by age rather than rock types. Geologists are very much concerned with the geological history of an area and prospectors should note that mineralization of a certain type is often associated with rocks of a particular age in any area. The age terms used by geologists are given in Table 8-1 which is a simplified version of what is known as the **Geological Timetable** or **Geological Column**.

TABLE 8-1. GEOLOGICAL TIMETABLE OR "GEOLOGICAL COLUMN"

ERA	Map Symbol	PERIOD	Map Symbol	Approximate Years Before Present (Millions)
Cenozoic	C	Quaternary	Q	1.6
		Tertiary	T	66
Mesozoic	M	Cretaceous	K	144
		Jurassic	J	208
		Triassic	Ŧ	245
Paleozoic	P	Permian	P	286
		Pennsylvanian	P	320
		Mississippian	M	360
		Devonian	D	408
		Silurian	S	438
		Ordovician	O	505
		Cambrian	Є	570
"Precambrian" pЄ = older than 570 million years				

Notes: On a geological map:

1. Lower case l, m and u before the Period symbol means lower, middle and upper, and refers to rock units, eg.: uP = upper Permian (rocks).
2. Small-sized capitals E, M and L before the Period symbol means early, middle and late, and refers to time, eg.: ET = early Tertiary.
3. Lower case letters after the Period symbol usually means some rock type, eg.: v = volcanic, s = sedimentary, g = granite family, etc., eg.: Kv = Cretaceous volcanic rocks.
4. Small-sized capitals after the Period symbol refer to a particular rock formation, eg.: ŦSR = Triassic Spray River Formation.
5. You may see the "Carboniferous" Period — symbol C — on older maps. It includes the Mississippian and Pennsylvanian.

For prospectors, mapping by rock type is the practical thing to do. Geologists do this too, and later attempt to assign ages to the rocks. Some Additional Notes on the preparation of geological maps are included at the end of this chapter. Prospectors who have some idea how geological maps are made will be able to get more value from published maps and can attempt to map their own claims.

PLANNING FIELDWORK

The following are some suggestions for planning your fieldwork:

(1) Go only into country you can handle. You must be realistic about your physical condition and capabilities.

(2) Do not go alone if at all possible. The reason for this obviously is safety. However, a team of two prospectors is generally more efficient and productive than two people working alone. In addition, the costs of travel, equipment, and food per person will be reduced.

If you cannot find a compatible partner and must work alone, be sure some reliable person knows where you are going and when you plan to return.

(3) Make every effort to research your intended area beforehand. A visit to your District Geologist is the best way to start. He will know or can find out about the area you are considering, what work has been done there, what geological and topographic maps are available, and whether the area is considered to have good potential or not. His office will also have some information on claims in the area, although the most up-to-date information is carried at the Gold Commissioner's offices. You will also be able to consult the following valuable research aids:

- (a) MINFILE — A file of known mineral deposits or occurrences in the province. Outline maps show locations, and each entry includes a brief summary of the geology and mineralization, and a list of references from which further details may be obtained.
- (b) Assessment Reports — These are reports on properties filed by companies and prospectors to keep claims in good standing. Outline maps show the location of the properties.
- (c) Government and other publications — These include various bulletins, papers, reports, and other publications from Federal, Provincial and other agencies; they can provide a wealth of information on many areas or properties.
- (d) Technical and Trade Publications — These include books, bulletins, journals, trade papers, newsletters, and newspapers.

(4) Know what Mining Division you will be in and where you must record claims. This information can be obtained at any Gold Commissioner's or District Geologist's office.

(5) In addition to all the necessary equipment and supplies needed for a prospecting trip, be sure you have the following (Fig. 8-4):

- (a) A valid Free Miner Certificate.
- (b) Claim tags.
- (c) Nails for claim tags.
- (d) Geological supplies: acid bottle, compass, flagging or spray paint, geological hammer, magnet, magnifying glass, penknife, sample bags, streak plate.
- (e) Maps of the area and air photographs if it is a small area.
- (f) Diary or notebook.

IN THE FIELD

INTRODUCTION

The following are some suggestions you should follow once you are in the field:

(1) Keep a diary or notes. Stop and record where you go, what you see, and what you do. Do not trust all these details to memory at the end of the day or end of the trip. You do not have to produce a literary masterpiece, just something that you can follow. Perhaps the simplest system is to mark out your route on a map or air photograph with numbered stops, then opposite the numbers in your diary describe what you saw at each stop.

(2) Look for outcrops and signs of mineralization. The most likely places for outcrops are along banks of creeks or streams, in stream beds, along the shore lines of lakes, on steep slopes, and along the tops of ridges. On flatter ground look along road cuts, logging trails, and hydro or other rights-of-way. Outcrops or rock fragments from outcrops can sometimes be found in the roots of blown-down trees (Fig. 8-7).

(3) Examine **talus** on steep slopes. Talus is rock waste that has fallen or rolled down-slope; it accumulates at the bases of open slopes, usually in more rugged terrain. You may be able to save yourself a climb to look at the rocks in place.

(4) Follow the contacts of igneous intrusions if possible, examining outcrops on either side of the contact.

(5) Arrange your traverses to cross the general strike of rocks. This way you will see the most rock types. However, if you find signs of mineralization restricted to one particular rock type, then follow it along strike.

(6) Follow faults in both directions if possible, especially if a fault shows any signs of alteration or mineralization in or near it.

(7) Faults often go in families; they tend to follow the same general direction or directions in a given area.

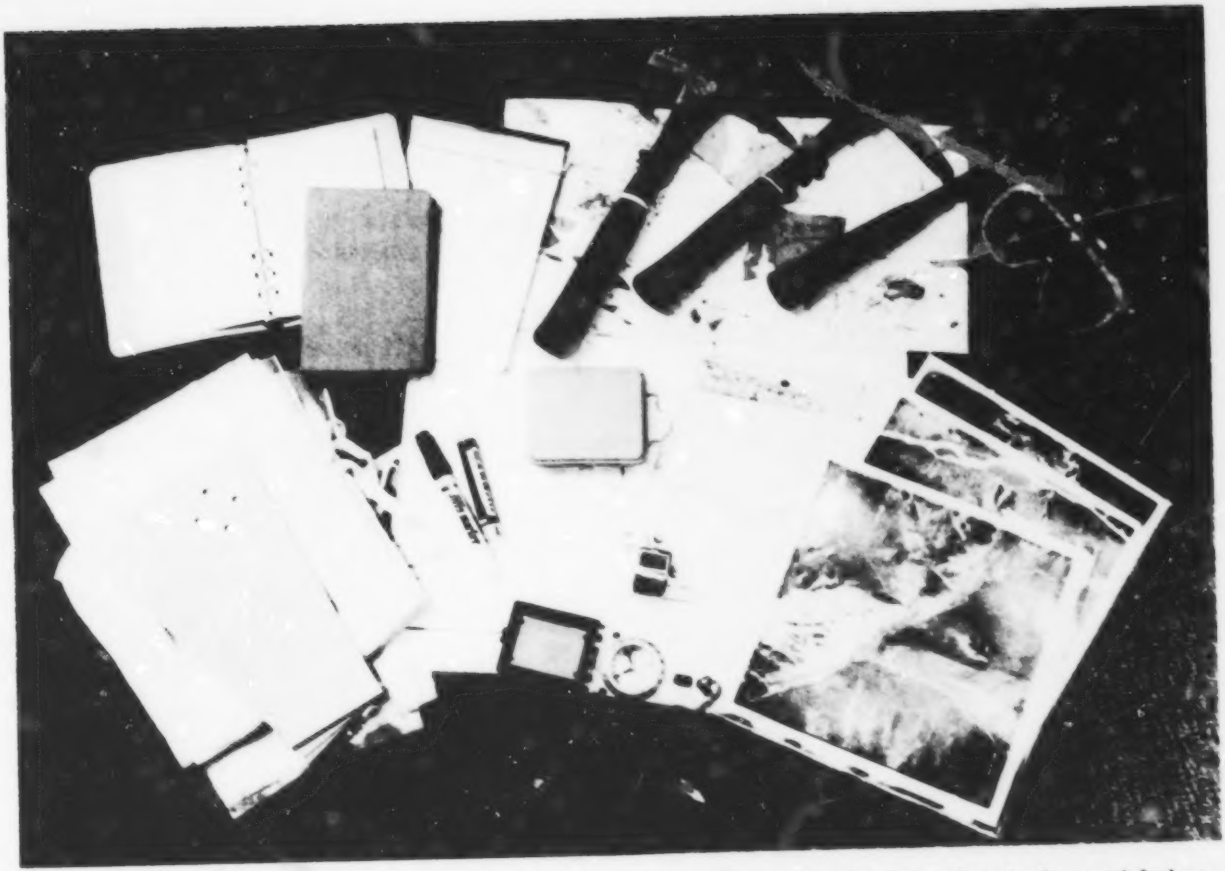


Figure 8-4. Examples of field equipment for prospecting. (Underneath: topographic and geologic maps. Clockwise from top left: three styles of field notebook; geologic hammers — pick and chisel type with fibreglass handles, all-steel chisel type; eye protection; air photos — one in a protective plastic cover; compasses — Silva above and Brunton below; plastic and cloth sample bags with a paper soil sample bag on top. Centre: felt-tip markers; first aid kit; two styles of protractor for plotting traverses; hand tally counter.)

(8) Look closely where faults enter different rock types, change direction, or intersect each other, and where igneous intrusions seem to be broken up by a large number of small faults or fractures.

BREAKING ROCK

Whether you find suspected mineralization in outcrops, or in float on the surface, in overburden, or in streams, chances are that it will be weathered. Most mineralization contains some iron sulphides and weathering turns this into rusty iron oxides and produces sulphuric acid. The acid causes further breakdown of the mineralization. This is how gossans are formed.

Unmineralized rocks also weather and rocks rich in iron minerals often weather into material that is difficult to tell from weathered mineralization or gossan. So, to tell what type of rocks you are looking at, or to find unaltered mineralization, you must break the rock. The type of hammer you use is a matter of personal choice, but hammering rocks can create both rock and metal splinters which may fly off at high speeds, so wear work gloves and protect your face and eyes. Wetting a rock surface, especially a freshly broken surface, will often reveal details that are not obvious on a dry surface.

TRACING MINERALIZED FLOAT

Some details on the formation and tracing of float in overburden are given in Chapter 11 which deals with placer deposits. It is worthwhile checking streams and gravel bars for mineralized float. If the float is very hard, smooth, and shows little or no signs of weathering, then it may have travelled far or may even have been dumped in the area by glaciers and found its way into the stream. Soft, irregular, or angular fragments and weathered float are another matter, especially if plentiful. Trace the float upstream and into any

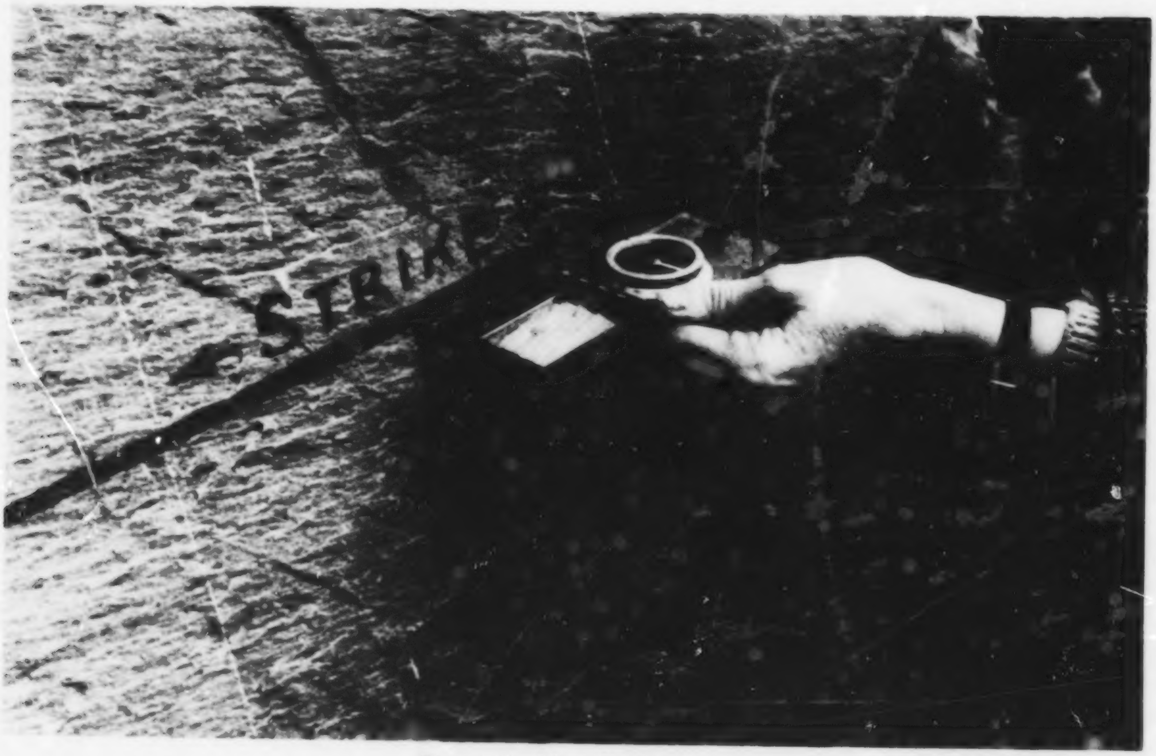


Figure 8-5. Measuring the strike.

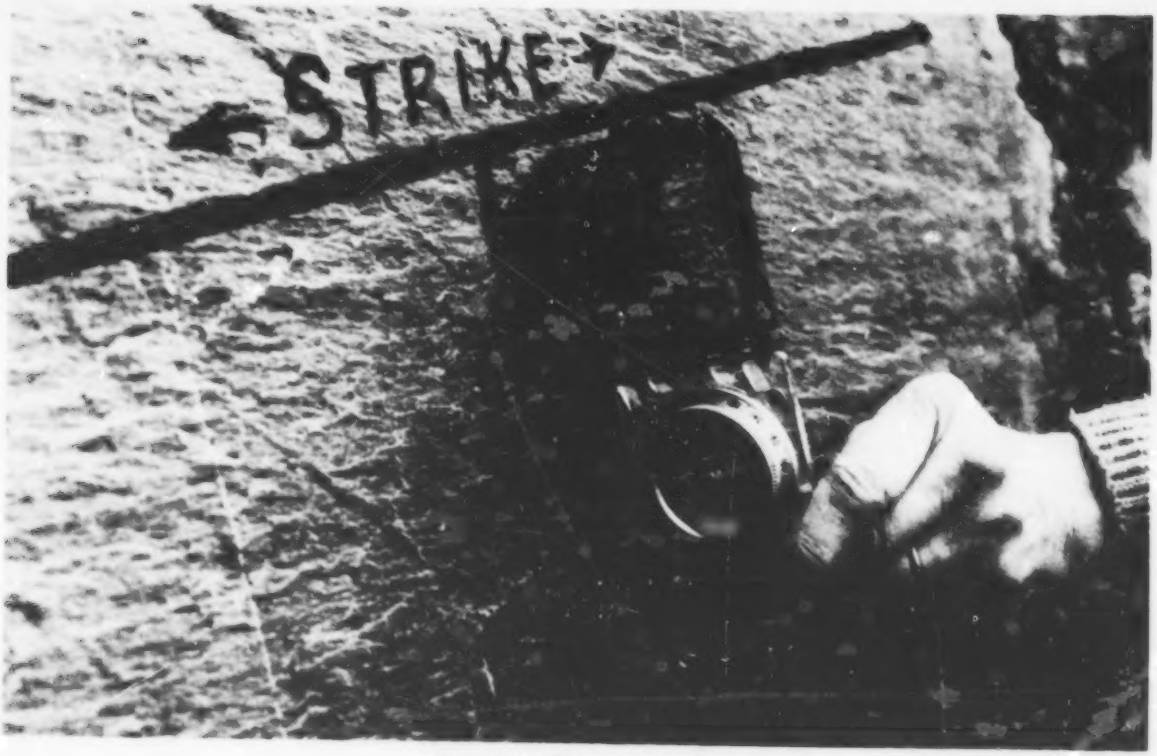


Figure 8-6. Measuring the dip.

Figure 8-7. Rock fragments from outcrop in roots of blown-down tree.

tributaries and check the stream bed for outcrops at the farthest point upstream that you find any float. Then check the banks and slopes on either side for float or outcrops.

TRACING MINERALIZED TALUS

Examination of talus is always worthwhile and if you find mineralized talus then the source is probably immediately up-slope. Rugged terrain is almost certain to have been glaciated and there may be glacial deposits at the bases of slopes too. Talus fragments should be irregular and angular. Smooth, rounded, and heavily scratched material is of glacial origin.

TRACING MINERALIZED MORAINE

Moraine is rocky material of all sizes picked up or gouged out of bedrock by a glacier and left behind when the glacier melts or "retreats". As indicated above, fragments should be at least partly smoothed, with some rounding of edges and scratches on any flat surfaces. There are some notable prospecting finds from tracing mineralized moraine back to its source, and there have even been mining operations beneath glaciers. However, I would not recommend tracing mineralized moraine in rugged country to beginning prospectors, unless you already have the knowledge, equipment, and experience for working safely on or around glaciers.

MINERALIZED OUTCROPS

As mentioned, these are likely to be weathered too, so be prepared to spend some time and effort to break into fresh mineralization. Try to get an idea of the type of mineralization from the weathering also — look for characteristic stain colours. Panning crushed weathered mineralization or gossan may reveal traces of gold or other minerals that are not otherwise visible. Is it disseminated or in veins or shear zones? If in veins or shear zones, try to get an idea of the strike.

STRIPPING AND DIGGING

Removing overburden from an outcrop area is called **stripping**. It is done, obviously, to clean off the outcrop and to see how far any mineralization extends. Dig around the edges of outcrops to start with and if the digging gets too deep you can try digging shallow holes at spots along the strike of any mineralization or, if it is disseminated, anywhere in the area where you think shallow holes might reach bedrock. Such holes are called **test pits**. If a little digging fails to uncover more mineralization near your first discovery then you should search farther afield for other mineralized outcrops. If you have a soil geochemistry kit, a few soil tests may indicate good places to try test pits.

TRENCHING

Trenching by hand is laborious and time consuming. You should consider hand trenching only when you think there is a very good chance of a worthwhile result. For example, you could trench through a weathered vein to get a proper sample of fresh mineralization or dig trenches along the strike of a well-defined vein.

Note that you are currently required to submit a **Notice of Work** for any proposed program of test pitting or trenching on claims to the District Inspector and Resident Engineer for the Mining District in which your claims are located (*see* Chapter 9).

Unless very shallow, test pits and trenches should be filled in when you have finished with them, otherwise they may be a hazard.

OPEN-PIT OR UNDERGROUND PROSPECT?

Mineralization in a single vein or a shear zone that has a good strike length but not too much width would be an underground prospect. The key point to remember is that the minimum underground mining width is 1.5 metres or about 5 feet. Spectacular assays of veinlets a few centimetres wide may be quite unspectacular when "diluted" to 1.5 metres. Narrow veinlets are also less likely to continue very far along the strike or down the dip. Veins often come in groups having the same general strike, so you should always look for other veins parallel to your first discovery.

Disseminated mineralization that may not be of high grade, or mineralization confined to narrow veins, veinlets, or joint surfaces, that occurs in outcrops over a large area, would be an open-pit prospect. The key point to remember is that all the ground in the mineralized area must be mined, even if some of it is waste, so you must find enough scattered mineralization for a company geologist to feel there is a chance that such an operation would be profitable.

LOVE AFFAIRS

Finding mineralization is always an exciting event, especially for beginners. After all, it might well change your life. Unfortunately, some prospectors seem quite literally to fall in love with worthless prospects. They have found a little mineralization, but never seem to be able to find any more and they can never get any company to take an interest in their claims. Yet every year they are to be found digging away on the same claim in the hope that this year will be different. I have even had one such person tell me that he had spent too much time and money on his claim to give it up! Like other love affairs with worthless prospects, the results are disillusionment, broken dreams, and a greatly reduced bank balance.

You must at all times be realistic about what you find. If you cannot find the source of those few pieces of float or that geochemical anomaly, then move on. If you find an area riddled with quartz veins, but all assays for gold come back "nil", then get the message.

It is difficult to generalize, but it should not take you more than a field season to find out if your prospect is worth trying to get a deal on. It may only take you a few days of hard work. If you think you have a good prospect, it might take you a couple of years to get a deal on it for you are bound to get several refusals and you should not abandon a property just because you get a couple of "no's". You might want to hang onto some claims even if there is not much on them, if they happen to be in a "hot" area, as someone might want to buy them from you — but this is speculating, not prospecting.

Beginners especially may genuinely not know whether what they have found is enough to interest a mining company. Your District Geologist will be able to give you advice on this and, depending on the situation, he may be able to look over your prospect with you.

ADDITIONAL NOTES

(1) TIPS ON THE USE OF A COMPASS

Introduction

If visibility is relatively unrestricted and you have a large-scale air photograph or topographic map, it is usually quite easy to find your way around without the aid of a compass. If the ground is relatively flat and featureless and you cannot see far because of trees, then you must use a compass for accurate travel. Even so, there will be times when you are not sure exactly where you are. With some care you will be able to keep these situations to a minimum and know how to get out of them.

Traversing

Basically a traverse is a straight line from one prominent landmark to another. "Prominent" means the landmark can be identified on the ground as well as on a map. First draw a line on the map joining the chosen landmarks and measure the distance using the scale of the map. The next task is to measure the direction you wish to travel. A compass graduated from 0 to 360 degrees requires that you measure the angle clockwise between true north and the direction of travel. This angle is called the **azimuth**. There are many ways to do this, depending on the type of compass or other equipment you have. A common way is to extend the traverse line with a ruler until it cuts one of the edges of the map, which will be a N-S or E-W line, and then measure the angle at this point. If you are taking a prospecting course your instructor will show you how to do this and how to do any calculations needed to get the azimuth. If you are on your own, be sure you understand this step before you go into the bush!

In the field, at the starting point of the traverse, you make sure your compass is set for the declination, set or "dial in" the azimuth, and aim it in the required direction, following the procedures for your particular make of compass. When aiming, hold the compass away from your body or at arm's length and look for some feature in the required direction — for example, an easily recognized tree — then set out for it. When you reach it repeat the procedure until you reach the chosen landmark at the end of the traverse. Depending on circumstances, sighting may vary from a casual glance now and then to make sure you are "on course" to careful sightings every 50 metres or so.

It is very difficult to keep exactly on course by this method. With local variations in the magnetic field, problems with the terrain and human error, you will be doing well if you wander off your intended direction by less than 5 degrees, especially on your first trip. For this reason you should avoid long traverses or small landmarks that might be easily missed at the ends of your traverses.

Keeping Track of Distances

It is not easy to keep accurate track of distances along a traverse. If you find something that you want to be absolutely sure of finding again you should flag or blaze a clearly marked trail back out to some convenient point, rather than relying on compass directions and estimated distances.

A common way of estimating distances is with measured paces. Set out a measured distance on level ground, say 100 metres, and walking naturally, count the number of paces (left + right = 1 pace) required to cover the distance. Take the average of several walks in both directions and note it down. On a traverse you count paces, preferably with the aid of a hand or **tally counter** and record the number of paces to any features of interest. You can then convert paces into distances with simple arithmetic. The disadvantage of this method is that the bush is seldom as free of obstacles or as level as the ground you measure your paces on, so your measurements could be far less accurate.

An alternative is just to count paces. One common way is to count every four steps or two paces and count 1 on the counter. You can assume this is roughly 3 metres or 10 feet. You record the total count for the traverse and again the distance of any feature of interest on the traverse is determined by simple arithmetic. For example, an outcrop found at 150 counts along a traverse of 450 counts would be 150/450 or one-third the way along the traverse.

Measuring claim lines requires a much more accurate method. Two people in a team can use a chain or a measured length of thin plastic rope. One person can use a hip chain, which is a device worn on a belt. It pays out a fine cotton thread through a distance-measuring device. For additional details, *see* Chapter 9.

Planning a Traverse

Common sense and care can save problems in the field. Consider the situation on Figure 8-8. Assume the scale is 1:50 000 and an air photograph suggests there are some outcrops in the area of interest that you would like to look at. You park your vehicle at "A" and make your first traverse to "B", the end of the pond. If you wander to the left you might hit the pond at point "C". But suppose you wander to the right? If the bush is really dense you might not see the pond when you get near it at point "D". Have you gone far enough? Have you gone too far? How do you know which? Do you keep going to make sure? In an extreme case you might keep going beyond the lake and the area of interest. There is certainly a chance you will get lost. True, you could always head south back to the road, search for your vehicle, then start again!

Suppose this time you set your traverse for point "C" (Fig. 8-9). If you wander to left or right you should still hit the pond. Better yet, set your traverse for point "E". This way if you wander right you will surely hit the pond and if you wander left you will hit the creek. Either way you will know how to get to point "E". But suppose the creek has dried up and you miss it and you go off in the direction of "F"? In this case, just keep going. You have a backup landmark, the lake, which you will get to sooner or later.

Planning traverses this way may mean some extra walking but it greatly reduces the chances of error or getting lost.

(2) GEOLOGICAL MAPPING

A typical mapping project begins with library research and the study of existing reports and old maps. Then an extensive study of air photographs is made. Thus the geologist in charge may get a good idea of what to expect before the fieldwork even begins.

A field party consists of at least two people and for a large project such as a 1:250 000 map sheet there may be several geologists and assistants and it may take two or three field seasons to complete the project. Using the 1:250 000 example again, traverses would be planned to cut across the expected contacts, structures, and strikes. At this scale, 1 centimetre = 2.5 kilometres, ideally the geologist in charge might like to have traverses about 3 kilometres apart so that no outcrop is more than 1.5 kilometres from any traverse. In practice, time, weather, and lack of funds might mean a wider spacing, especially in areas where the rock types or the structure appear to be simple. Geologists then rely heavily on air-photograph interpretation between traverses. You can easily see how at such a small scale only a small part of a map-area, in fact, is looked at in any detail.

Outcrops found along a traverse are examined and the information plotted on a map. A typical situation is shown on Figure 8-10. The procedure would be the same at any mapping scale. On the outward leg, somewhere between the outcrops of rock A and rock B there must be a contact between the two rock types. The same contact is crossed on the return leg. If there is no other information available, the contact is drawn halfway between the outcrops. However, the position of the contact is much more certain on the return leg (less room for error) than on the outward leg and this is reflected in the map symbols used. Usually a solid line means that a contact has been observed, a dashed line means that the contact is approximate, while a dotted line means that the contact is inferred or assumed, which means it is an educated guess.

Other information is plotted by means of special symbols that will be explained in the map legend. Always check to see what symbols have been used, particularly for faults, strike and dip, and mineral occurrences.

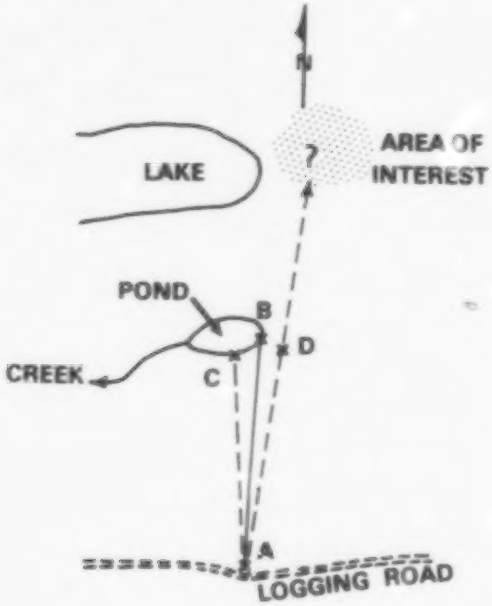


Figure 8-8. Planning a traverse — 1.

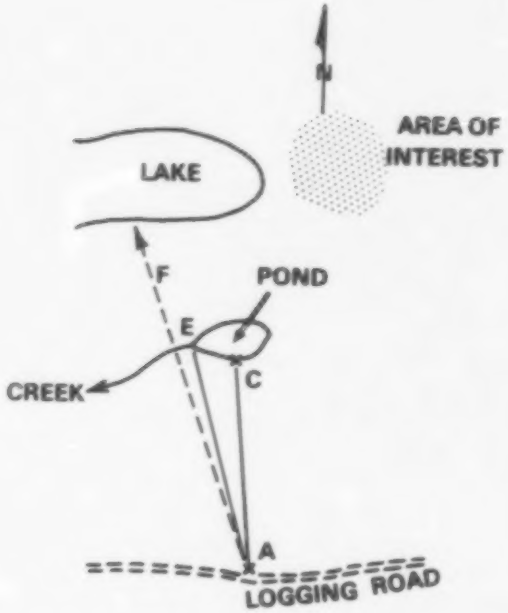


Figure 8-9. Planning a traverse — 2.

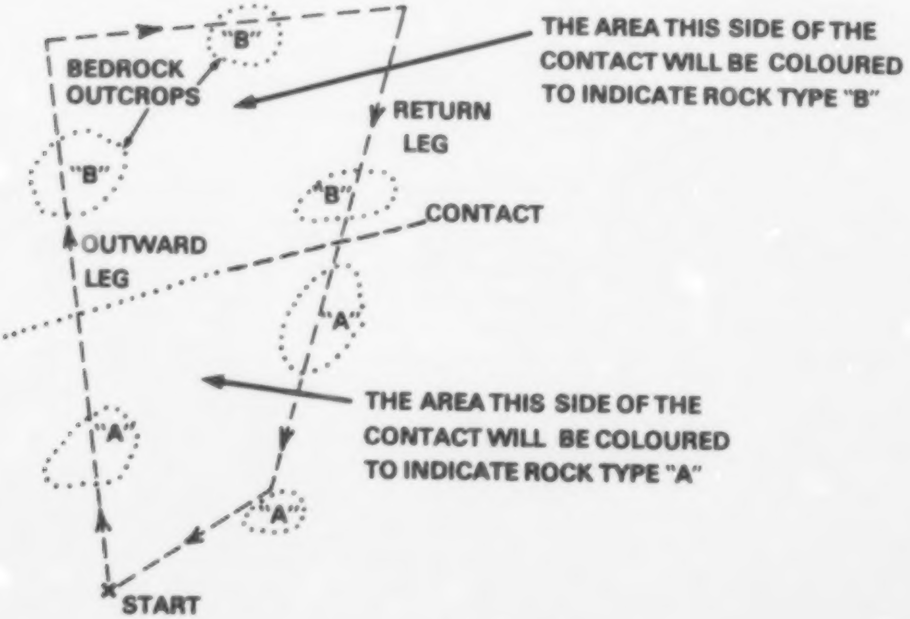

"B"
BEDROCK OUTCROPS
THE AREA THIS SIDE OF THE CONTACT WILL BE COLOURED TO INDICATE ROCK TYPE "B"
RETURN LEG
"B"
"B"
CONTACT
OUTWARD LEG
"A"
THE AREA THIS SIDE OF THE CONTACT WILL BE COLOURED TO INDICATE ROCK TYPE "A"
"A"
"A"
START

Figure 8-10. Geological mapping.

CHAPTER 9 — CLAIM STAKING AND LEGAL REQUIREMENTS

INTRODUCTION

Proper claim staking and recording are important requirements of prospecting. Unfortunately they are often poorly or improperly done and the legal requirements for obtaining and keeping title to claims are often poorly understood.

The reasons for this are many and include laziness on the part of the prospector, difficulty in understanding legal jargon, a natural dislike of "red tape", a feeling that details are "not important", and the regrettable fact that government rules and regulations can change.

There is a good chance that some of the information which follows may be out-of-date by the time you read it. It is therefore essential that you make sure what the current regulations are and watch out for changes.

A comment sometimes heard in the mining industry is that you can tell how good a property is by the number of lawsuits it has generated! Certainly if you ever find anything really outstanding, perhaps enough to start a staking rush, some companies or individuals will check every detail of your claims to see if your title is completely sound; if it is not, they will try to obtain title to the land themselves.

Currently it is Ministry policy in cases of dispute to determine whether the prospector made an "honest attempt" to comply with the law and to overlook minor imperfections in staking or recording. Some court decisions also appear to have regarded people disputing a prospector's title on the basis of some technicality as "claim jumpers".

Nevertheless, taking deliberate short cuts could easily cost you title to a property, so consider yourself warned! Take care when staking and recording and allow yourself adequate time to do the job properly.

REQUIREMENTS FOR STAKING

Currently, the requirements for obtaining and keeping title to mineral claims or placer leases are set out in the *Mineral Tenure Act*. The Mineral Tenure Act Regulations describe in detail how the act is to be interpreted. A booklet is also available for mineral and placer claim staking; it explains in nontechnical language, complete with illustrations, the procedures and requirements contained in the acts and regulations.

These publications are available from any Gold Commissioner's office, Sub Recorder's office, or District Geologist's office. For this reason this chapter will not repeat all the many details in these publications, but will deal with claim staking and legal matters in more general terms.

Free Miner Certificate (CMC) — This is the first requirement and it must be obtained before you attempt any staking. The "Free" part does not refer to the price; it just means that you can stake claims on vacant mineral land. Further, if you are staking as an agent for another person, that person must also have a Free Miner Certificate (*see* Fig. 9-1).

Claim Tags — Currently three types of tags are available; those for staking mineral claims on the Modified Grid and on the 2 Post systems and those for placer claims. Note that the tags are not interchangeable.

Nails — Tags must be "affixed" to claim posts. Nails are not the sort of thing you can make or substitute for in the bush, so do not forget them! Ordinary nails will rust, so use galvanized nails or, better still if you can get them, aluminum nails.

Notebook — The information you put on the claim tags must be copied exactly onto the recording forms later, so use a notebook, never trust to memory.

Compass — Check the declination to be sure it is properly set before you start staking.

Cutting and Marking Claim Lines — Staking requires some claim lines to be marked. This does not mean that some sort of footpath or trail must be cut, with all trees felled and underbrush cleared out. The law requires only that the claim lines be "clearly and permanently marked" and each mark must be visible from the next mark along the claim line in either direction. This can be done with a lot less time and effort (and less damage to the environment) than by cutting out and clearing a path.

The usual and preferred method of marking a line is to blaze standing trees along the claim lines so that the blazes face along the line. Paint and plastic flagging are often used, but flagging is not as "permanent" as blazing. At high elevations, above tree line, cairns of rocks are easy to construct, but in rocky terrain use paint or flagging to mark each cairn, otherwise they are difficult to spot.

Measuring Distances — You will need to measure distances fairly accurately to get your claims the correct size. As mentioned in the fieldwork chapter, the two most convenient ways of doing this are with a surveyor's plastic "chain", a marked plastic rope, or a "hip chain". The first two methods require a partner. A typical procedure would be for prospector "A" to sight along the claim line and guide prospector "B" along this direction, dragging the chain along the ground. When the end of the chain reaches "A", he or she calls out and "B" stops. "A" then joins "B", blazing the line on the way. The procedure is repeated until the claim line is completed.

If there are any steep slopes on the claim lines and if you cannot locate yourself accurately with air photographs, you will need some **slope correction tables** to correct distances measured up or down slopes to true horizontal distances (*see* Table 9-1). Note that the corrections are very small for slopes

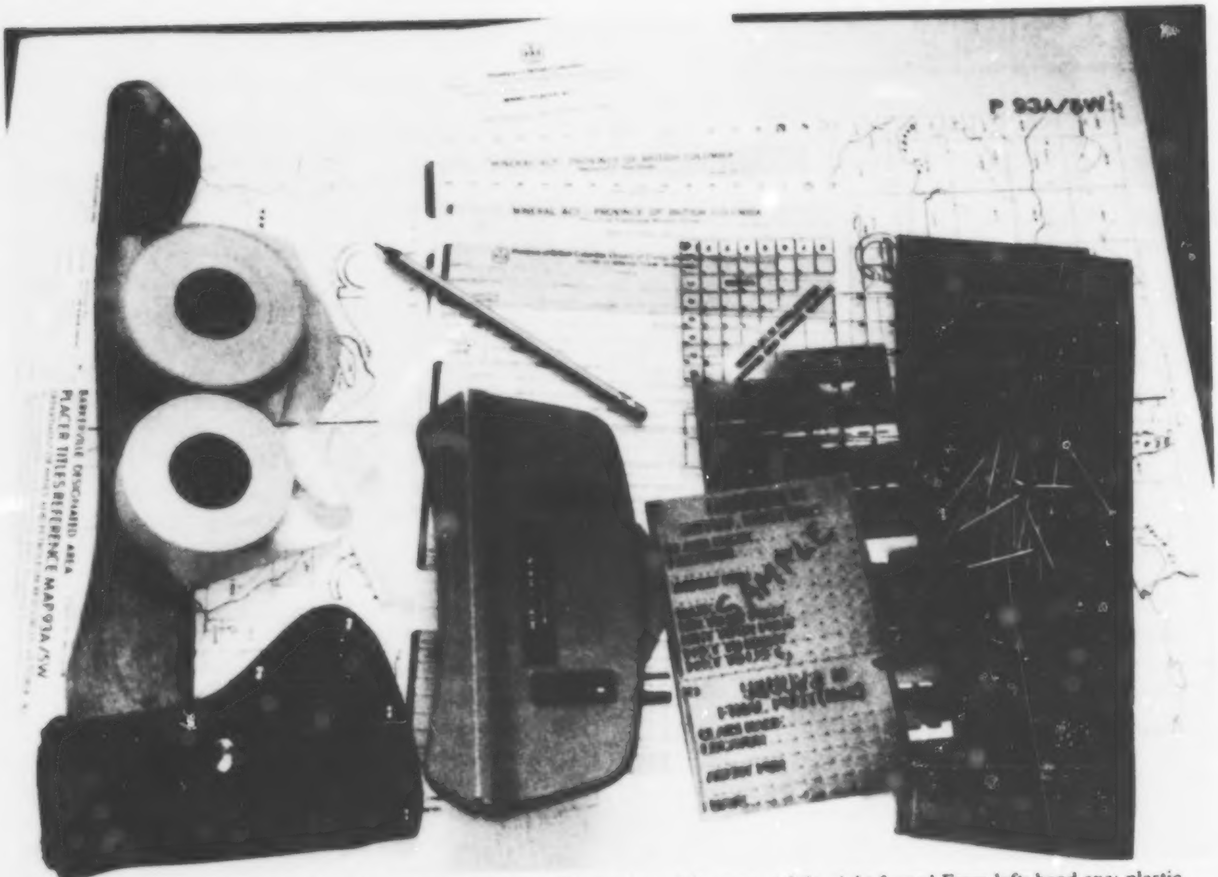


Figure 9-1. Examples of field equipment for staking. (Underneath; a claim map and the right forms! From left: hand axe; plastic flagging; an old ball-point pen for marking claim tags — you can also use a nail; belt or hip chain; 2-Post, Placer and Modified Grid claim tags; a plastic template for plotting claims; the all-important nails!)

less than 20 degrees. You will also need some means of measuring the angle of the slopes. The clinometer or dip needle on your compass will be accurate enough for this purpose.

Maps and Air Photographs — You must determine the location of any claims you stake so you will need a topographic map of adequate scale, such as 1:50 000. If you are working with air photographs, you will still have to transfer locations to a topographic map.

It is a good idea to carry a copy of the claim map for the area where you are staking. Not only will it have the location of current claims, with their names and claim tag numbers, but you must record your claims on a Mineral Titles reference map located in the Gold Commissioner's office.

STAKING MINERAL CLAIMS

Currently there are two methods available for staking mineral claims — the **Modified Grid** method and the **2 Post** method. They are quite different and each method has advantages and disadvantages. The 2 Post method is restricted in use to prospectors; it is actually a leftover from older legislation as a concession to old-timers. This method may not survive the next major changes to the *Mineral Act*.

Again, it is up to you to be familiar with the latest version of the *Mineral Tenure Act* and the Mineral Tenure Act Regulations. What follows is merely an outline of each method. If in doubt, check with your nearest Gold Commissioner's, Claims Inspector's, or Mines Inspector's offices.

Modified Grid Method — A claim consists of up to 20 units, each unit being a square with 500-metre sides. A claim is located by a **Legal Corner Post (LCP)** (Fig. 9-2) and three other **Corner Posts**. The boundary or perimeter of the claim, as defined by the corner posts, must be marked. Claim lines must run north-south and east-west.

2 Post Method — A 2 Post claim is also square but with a side equal to a maximum length of 500 metres (this is the metric equivalent of 1640 feet). The claim is located by means of a **Location Line**. An **Initial Post** or **No. 1 Post** is set up at one end of the line and a **Final Post** or **No. 2 Post** is set up at the other. The Location Line must be marked, but it can run in any direction. The claim may be on one side or the other of the Location Line or partly on either side, as long as the total width is no more than 500 metres or 1640 feet.

TABLE 9-1. SLOPE CORRECTION TABLES (TO 50 DEGREES)

To Get a True Horizontal Distance of 100 Metres:

If Angle of Slope Is (Degrees)	You Measure Along Slope (Metres)	If Angle of Slope Is (Degrees)	You Measure Along Slope (Metres)
5	100.4	32	117.9
10	101.5	34	120.6
15	103.5	36	123.6
18	105.1	38	126.9
20	106.4	40	130.5
22	107.9	42	134.6
24	109.5	44	139.0
26	111.3	46	144.0
28	113.3	48	149.4
30	115.5	50	155.6

Horizontal distances other than 100 metres are found by simple proportion; for example, if you want a true horizontal distance of 120 metres on a 20-degree slope, you measure $106.4 \times {}^{120}/_{100} = 127.7$ metres along the slope.

Comparison of the two Methods — With the Modified Grid method the size of your claim is determined by the number of 500-metre by 500-metre units you stake; this area is marked on the claim map. It is located by the position of the Legal Corner Post (LCP), regardless of minor errors in the length or direction of your marked claim lines. Generally, you must mark over twice the length of claim lines with this method compared to 2 Post claims covering the same area.

In practice, it is sometimes difficult to get the last side of the Modified Grid claim to "close" on the LCP. With a large claim in heavy bush the LCP may be nowhere in sight when you have measured out that last side. There are some ingenious ways of getting around this problem, such as sending your partner back around the claim lines to the LCP to shout! However, these all take time and adjustments must be made to the claim lines to get them to "close".

With the 2 Post method, as long as you do not exceed the size limit, you get the ground you stake, regardless of whether it corresponds exactly to what is marked on the claim map. The single Location Line can be placed to suit the geology or the terrain. The main disadvantage of the 2 Post method is that it is very easy to create small pieces of unstaked ground called **fractions** between 2 Post claims.

GROUND AVAILABLE FOR STAKING

Currently you can stake mineral claims on the following:

(1) Any vacant mineral land.

(2) Previously staked ground if the claims have been allowed to expire.

(3) Ground covered by valid placer titles.

Currently you can stake mineral claims on the following, but you may find there are restrictions, limitations, or other problems that you will have to deal with:

(1) Certain rights-of-way, such as B.C. Hydro rights-of-way.

(2) Flooding reserves.

(3) Wildlife or other land management areas.

These three classes of land are marked on claim maps as "subject to conditions". It is up to you to find out from the Gold Commissioner's office what these conditions are and to comply with them.

(4) Private land. This is a problem area. Very little private land in British Columbia includes title to mineral resources, so in theory you can stake on private land. However, your Free Miner Certificate does not give you the right to trespass on fenced and "posted" land nor on any cultivated land. "Cultivated" is interpreted as "used for producing a crop" and includes orchards and hay fields. Also you cannot cut trees on private land to make claim posts or to mark claim lines without the owner's permission; he or she can make you carry in your own posts.

You are, of course, liable for any damage done while prospecting on private land. You may have to compensate for or make good any damage done, to the satisfaction of the owner, and the owner may decide to be difficult to satisfy. Also the owner can require you to put up a **security bond** to cover possible damage.

In practice, a private landowner can make it very difficult and expensive for a prospector to prospect on his or her private land and your chances of making a deal on a property that is partly or entirely on private land are likely to be much reduced if you have upset the landowner in any way.

Obviously, the best approach is to consult the landowner fully and openly before you attempt to prospect on private land. Explain that your chances of finding anything worth exploring are low and make it clear what the implications are for the landowner if you find anything you want to stake. Many landowners may be quite cooperative and supportive if you promise them a "piece of the action". If you do this, be sure you put it in writing and include this commitment in any deal you make with a company.

The Free Miner Certificate was set up many years ago when society did not place as high a value on private land as it does today. The Certificate grants privileges with respect to private land that would almost certainly not be granted today. You have a responsibility to yourself and other prospectors to avoid complaints and not to abuse these privileges, otherwise they will be lost.

Currently you cannot stake mineral claims on the following:

(1) Any park or ecological reserve.

(2) Indian reserves.

(3) City or municipal land.

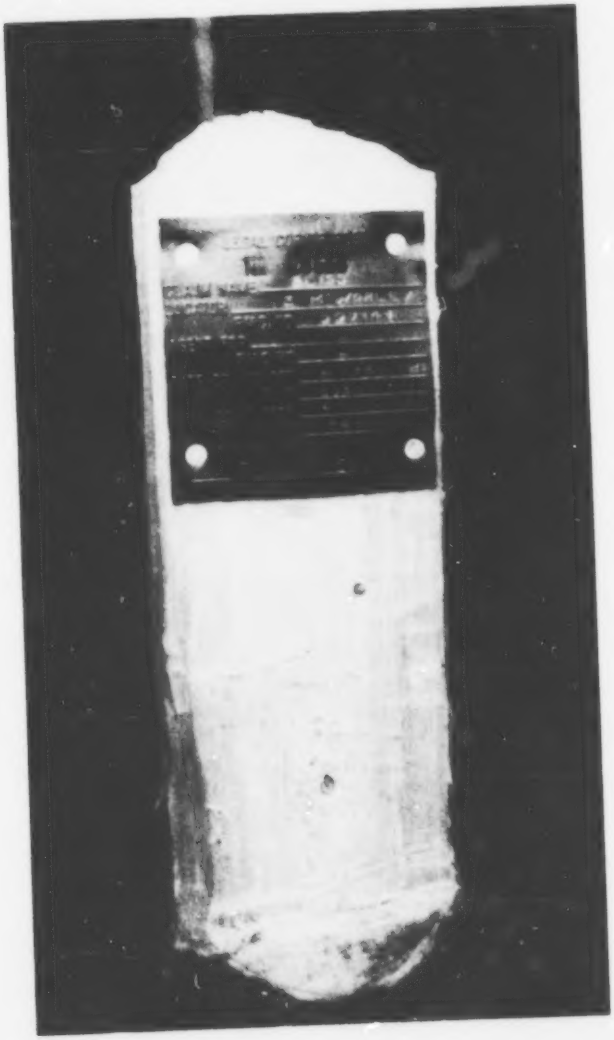


Figure 9-2. A legal corner post with a properly completed tag.

(4) Provincial or Federal Government reserves and certain rights-of-way marked on claim maps as "no staking allowed".

STAKING PLACER CLAIMS

The method for staking placer claims is similar to the 2 Post method of staking mineral claims.

There are important practical differences that you must be aware of:

(1) Currently you can only stake placer claims in Designated Placer areas; these areas are shown on maps at Gold Commissioner's offices, Sub Recorder's offices, and District Geologist's offices.

(2) A placer claim is 1,000 metres long and 500 metres wide.

These and other details are set out in the publications referred to earlier. Otherwise, the areas that can be staked or not staked, or staked with possible restrictions, are similar to those for mineral claims. You can stake placer claims on ground covered by valid mineral claims.

When staking placer claims take particular care with the placement of your Location Line and make sure that the position of your posts is very carefully described. Many creeks in Designated Placer areas are crowded with claims or leases and disputes over locations are common. This is particularly important with placer claims as mining operations may require the removal of posts and you must be able to re-establish the position of any post you remove.

RECORDING

Once staked, claims must be recorded at the Gold Commissioner's office or a Sub Recorder's office *for the Mining Division in which the claims are located*. Sub Recorders basically collect the forms and the required fees and forward them to the Gold Commissioner's office where the claims are plotted and the forms processed.

Once again, the full details and requirements for recording are contained in the current acts and regulations. The following are some general comments on recording matters that occasionally cause difficulties:

(1) The time limit for recording, currently 20 days after staking, applies to each claim, not to a group of claims you might stake over several days.

(2) Take care to complete all forms and sign them where necessary. Allow yourself time to do this without rushing and possibly making errors.

(3) Have the required fees.

(4) It is wise to carry some extra cash with you when recording in case you have overlooked some particular fee.

After you have recorded your claims you will eventually receive an official notification that your claims have been registered.

MAINTAINING CLAIMS AND LEASES

Once recorded you have a year to prospect or explore your claim. If you contemplate any work other than prospecting, especially if it involves ground disturbance, then you must complete a **Notice of Work** form and send it to the Inspector of Mines and Resident Engineer for the Mining District your claims are located in. You must obtain approval for your proposed work before you start.

Generally, if all you are proposing is hand work, approvals should be forthcoming with no problems. If you are contemplating mechanized work, then you will probably be required to post a **Reclamation Bond** which will be used to reclaim any workings or put right any damage, if your reclamation does not satisfy the requirements of the regulations.

The amount of the bond is set largely on the basis of the amount of surface disturbance proposed; you get the bond back, plus accumulated interest, if your clean-up is satisfactory.

Approvals for mechanized work usually pose no problems but they take more time; you must allow enough time for several ministries to process the paperwork. Depending on what you propose this may take 30 to 60 days. Of course, if you sign a deal with a company to work on your claims it will be up to the company to file the Notice of Work and seek necessary approvals.

In order to maintain your claims or leases in good standing beyond that first year you must do one of two things:

(1) Perform approved work on your claims to the required total value.

(2) Pay cash in lieu of work.

If you decide to pay cash the process is simple; you fill in the appropriate forms, pay the money, and the claims are yours for another year.

If you decide to do work then the procedure is much more complicated, especially for mineral claims. The Gold Commissioner will have a schedule of allowable work and the current rates for labour, equipment rental, living, and other acceptable expenses. This is changed periodically to reflect changing costs, so be sure to get the latest schedule. For a company doing work on your claims a professional geologist or geological engineer prepares and files an **Assessment Report** and completes the paperwork.

For the professional this is a routine job, but for the first-time prospector to submit what is more commonly known as a **Prospecting Report**, it is likely to seem an impossible task. There are indeed many rules and restrictions concerning approved work for prospectors, but the secret is to *check into the requirements beforehand* to make sure your proposed work will be the kind that is acceptable, and that you will do enough to satisfy the required total value. Then when you have completed the work you should allow plenty of time to go through the requirements step by step.

If you decide to submit a Prospecting Report your District Geologist will be able to show you copies of reports that have been accepted. Note that the Ministry does not expect the same standard of scholarship and skills from a prospector that it expects from a professional, and any prospector who can use a typewriter should be able to submit a Prospecting Report.

GENERAL COMMENTS

Beginners quite naturally have many questions to ask about claim staking and legal requirements. While many points can be cleared up with a careful reading of the appropriate regulations, there are some areas that are not as clear as they might be and these constantly give rise to questions.

(1) Buildings on Claims — Unfortunately some people have seen the staking of a claim as a cheap and easy way of getting a homesite and have put up cabins or even houses on them for year-round living. As a result of such abuses, buildings allowable on claims are now severely restricted. You can use campers, travel trailers, recreational vehicles, or any small mobile or moveable shelter for yourself or your equipment *while you are working on your claim.*

The intent is clear; they must be removed when you have finished work on your claim. Build anything at all "permanent" and you run the risk of finding some government officials on your doorstep armed with a document to remove you and a bulldozer or a box of matches to remove your dwelling. You will have to pay for the bulldozer too!

(2) Witness Posts — If you cannot place a corner post of a Modified Grid claim because of glacial ice, active slide areas, standing water, or inaccessible topography, the missing post or posts must be noted on the LCP tag. If you cannot place *any* required posts of a Modified Grid claim or *either* post of a 2 Post claim or placer claim for the above reasons, you can use what is called a **witness post** method of staking the claim. The details are explained in the appropriate regulations. This provision is commonly abused and is a frequent cause for the cancellation of claims. If you are able to place a post, even if it is difficult or time consuming, you should place it. Suppose you stake some ground using witness posts and someone else stakes the same ground but does not use witness posts. He or she has then demonstrated that witness posts were not necessary and the chances are that you will lose the ground.

(3) Restaking Lapses Claims — You can allow claims to lapse and then immediately restake them.

(4) Truncated Claims — These are claims that are incomplete or odd shaped because part of the ground is already taken by someone else's claims or by a "no staking" area. The act and regulations cover this situation very carefully.

(5) Fractions — Again, the act and regulations and staking guides cover the procedure for staking fractions clearly, but the regulations do not describe how they are created.

The most common ways of creating fractions are by overmeasuring distances and by using the 2 Post system. If you are greedy and put in claim lines or Location Lines that are longer than they are supposed to be, you only get title to the legal maximum size measured from the LCP or Initial Post. Thus you will have created odd-shaped gaps or fractions between your claims to which you do not have title. The situation is worse for the 2 Post method because the direction of the Location Line is not controlled and there are bound to be errors in the direction of any location line placed with a compass.

The last thing you want is to have someone else own ground inside your claims, especially if you have a "hot" property. It is therefore better to under-measure slightly. Many prospectors using the 2 Post method deliberately under-measure the length of their location lines and the width of their claims by 15 or even 30 metres to avoid creating fractions.

(6) Placer Mineralization or Hardrock Mineralization? — In some parts of the province placer gravels occur on top of mineralized bedrock that may be badly weathered and difficult to distinguish from packed overburden. In the old days, with only hand tools, it was easy to tell the difference between placer deposits and bedrock. Now, machinery that can remove any packed overburden can also remove some weathered bedrock as well; the problem is to decide when placer mining becomes hardrock mining!

Unfortunately the acts and regulations are not precise on the distinction between placer and hardrock mineralization. It is in fact a very difficult distinction to make. Some prospectors stake mineral claims over their placer claims to avoid potential problems. If you get into a problem of this kind, the best procedure is to reach a "gentlemen's agreement" with the other party. Failing this, you can make a formal complaint and get a ruling from a Claims Inspector or District Inspector.

(7) Disputes and Cancellation of Claims — A formal procedure exists to settle disputes over incorrect staking, overstaking, and related problems. The following reasons are the ones that most commonly lead to the refusal to register a new claim or to the cancellation of existing claims:

  (a) Incomplete or inaccurate forms for the registration of new claims.

  (b) Vague or inadequate descriptions of the location of LCP's or Initial Posts.

  (c) Failure to place required posts.

  (d) Unjustified use of witness posts.

  (e) Failure to mark the boundary of a Modified Grid claim or the Location Line of a placer claim or 2 Post claim. Some prospectors do not want other people to know where they have staked but if other people cannot find your claims, you may be overstaked and if a Claims Inspector cannot find your claims, then you are in serious trouble!

  (f) Failure to meet the deadline for filing assessment work or cash in lieu of work.

Deliberate violations of the law are hard to guard against. As is so often stated, laws are for the honest people. The old warning "stake and record before you talk" should be followed. A good practice is to take photographs of LCP's, corner posts, Initial Posts, etc., preferably with your marked claim lines clearly visible. Take one photograph of the LCP to show the location and claim lines, and a close-up to show the writing on the claim tag. "Before" and "after" photographs of violations can often prove your claim. A good trick is to hold up the front page of the latest daily newspaper so it appears in your photographs beside the LCP. This way if a claim jumper comes in and cuts down your posts and then states that he staked the ground 10 days before you were there, you have a photograph with a date to verify that you staked properly and when.

Unfortunately there is no certain method of protecting yourself from someone who is determined to bend or break the staking laws, short of posting people to watch over your ground day and night, but if you comply with the regulations you make it difficult for such people. The Ministry does cancel claims when there are deliberate violations of the staking laws, and it has suspended Free Miner Certificates in serious cases. You should also know that the names of individuals known or suspected of violations of the staking laws quickly become known throughout the industry; they soon find out that no company will deal with them.

PRACTICAL TIPS

The following are some suggestions that may help you avoid problems with your staking or difficulties with companies when you are trying to negotiate a deal.

(1) Stake on the Modified Grid system. Most companies do not like 2 Post claims.

(2) Stake enough ground. It is unlikely that anything small enough to fit into one or two units is going to be large enough to mine.

(3) Avoid witness posts. If you plan your staking with maps or air photographs before you start you can almost always avoid witness posts.

(4) If you use flagging to mark any feature of your claims, avoid blue; this is the colour commonly used by the Forest Service and logging companies.

(5) If you can make the trip to the Gold Commissioner's office for your Mining Division without undue delay or cost, do so. Sub Recorders do not plot claims, so if there is any problem you will find out quicker if you go to the Gold Commissioner's office.

(6) Get a copy of all the forms you file. This may be the only proof you have to show to a company that you have staked the claims until you receive the official notice that your claims have been registered.

CHAPTER 10 — GEOCHEMISTRY AND GEOPHYSICS

INTRODUCTION

Geochemistry is the study of the chemistry of rocks, minerals, and mineral deposits. Geochemical prospecting uses chemical tests in the search for mineral deposits by analysing stream or lake sediments, natural waters, soils, rocks, or vegetation for unusual traces of elements (almost always metals) caused by the presence of mineralization.

Geophysics is the study of the physical properties of rocks, minerals, and mineral deposits. Geophysical prospecting is the search for mineral deposits by measuring the physical properties of near-surface rocks, and looking for unusual responses caused by the presence of mineralization. Electrical, magnetic, electromagnetic, gravitational, seismic, and radioactive properties are the ones most commonly measured.

For reasons which follow, only a few geochemical and geophysical methods are suitable for use by a beginning prospector. Nevertheless, it will help you to have some understanding of geochemical and geophysical techniques because they appear in almost every exploration report. With some field experience and a little basic knowledge you may be able to take advantage of much free information.

SOME WORDS OF CAUTION

Along with surface mapping and sampling, geochemistry and geophysics are the workhorses of the exploration geologist. Perhaps because of this some beginners feel that they should be using geochemical or geophysical methods right away. Certainly an experienced prospector can make use of some methods, but for the beginning prospector I feel the choices are very limited, especially in geophysics. The beginner should first practice the basic skills of rock and mineral identification and careful ground search, and avoid getting heavily involved in either geochemistry or geophysics.

There are many reasons for this:

(1) Neither technique eliminates the need for careful ground search. At best they help localize areas for closer study.

(2) Some field experience is needed before a prospector can decide that geochemistry or geophysics might be useful and which method to use.

(3) The interpretation of the results of all but the simplest methods requires technical knowledge.

(4) Neither technique gives guaranteed results. Depending on the particular circumstances and method chosen, quite insignificant amounts of mineralization may give a good geochemical response, while high-grade mineralization may be undetectable. The great majority of geophysical responses are caused by some common rock combinations or structures or by worthless mineralization. High-grade mineralization may give no response if the wrong geophysical method is chosen.

(5) The purchase of geochemical supplies and the rental of geophysical instruments can be expensive; the purchase of most geophysical instruments is out of the question for the average prospector.

(6) Unfortunately in British Columbia, as in most parts of Canada, the effects of glaciation greatly complicate the use of geochemistry and may cause difficulties with some geophysical methods too.

GEOCHEMICAL PROSPECTING

Ore-forming processes, in addition to depositing ore minerals in veins or other bodies, may leave minute traces of mineralization in the host rocks or in zones of alteration. Such mineralization constitutes the **primary dispersion** and it may extend for some distance into the host rocks around mineable orebodies.

Weathering and soil-forming processes may result in traces of metals being leached out of mineralized zones and spread into soils. From the soil it may find its way into plants, stream, and lake waters and sediments. Such traces of metals from a mineralized zone form the **secondary dispersion**.

Geochemistry depends on extremely sensitive chemical tests that can detect the minute traces of metals in primary and secondary dispersions, and hopefully allow the prospector to track any dispersion back to its source.

The beginning prospector can do tests on stream sediments using kits that are commercially available. This is a good method for reconnaissance prospecting and for selecting areas for more detailed prospecting. A more experienced prospector may wish to test soils in selected areas, especially if there is little outcrop. Other geochemical methods, such as testing plant materials, rocks, or natural waters, should be left to the professional.

There are a large number of terms used in geochemistry and some of the more important ones are explained following:

(1) Units — Typically geochemical tests can detect minute concentrations of metals which are measured in **parts per million (ppm)** or sometimes **parts per billion (ppb)**.

(2) Detection Limit — This is the smallest concentration of a given metal that can be detected by the method in use.

(3) Background — Traces of metals can be found in sediments, soils, and plant material that are unrelated to any mineralization. They come from the weather-

ing of impurities that occur naturally in all rocks and are referred to as the **background**. The actual value of the background for any particular metal depends very much on the test method used, the type of material tested, the rock types in the test area, and many other factors. It may be high or low; it may vary little, or widely.

(4) Anomaly — Any concentration of metal noticeably above the average background concentration is an **anomaly**. Prospectors often want to know how many parts per million of a particular metal is "anomalous". Unfortunately there is no exact answer to this question. Generally if the background is quite low or uniform then a value of 2 or 3 times average background might be considered anomalous and possibly due to mineralization. If however the background fluctuates wildly, a value of 5 or 10 times average background might be considered anomalous. Geologists usually have several categories of anomalies, for example 2 or 3 times average background might be considered "slightly anomalous" or a **low contrast** anomaly; 5 to 10 times average background "anomalous" or a **moderate contrast** anomaly; and 50 to 100 times average background "strongly anomalous" or a **high contrast** anomaly. The size of the anomaly as defined by the number of adjacent anomalous samples is also important. A single strongly anomalous result might just be a freak, whereas a large area of moderately anomalous results might well be due to extensive mineralization. Typically geologists investigate the largest and strongest anomalies first and so should you.

The best source of information on background and anomalous concentrations in an area can be found in the Government Regional Geochemical Surveys if they have been done for the area you are interested in. If not, check for geochemical work in Assessment Reports on properties in the area. Your District Geologist may also have some information. Failing this it is a reasonable assumption that most of the values you obtain in any geochemical work will be background values!

Bear in mind that the simple tests you can do with most commercially available kits are less efficient than those used by companies or commercial laboratories. Thus the concentrations you measure may be lower for both backgrounds and anomalies than those from published studies for the area you are working in.

(5) Mobility — This term describes how easily an element moves once liberated from the primary mineralization by natural weathering processes. Of the metals most likely to interest the prospector and under most natural conditions zinc is the most mobile followed by silver and copper, then lead; iron and gold are the least mobile. Another way of putting this would be to say that a zinc anomaly will be much larger in area than a copper anomaly from the same mineralization. However, the strength of the copper anomaly might be greater than the zinc anomaly because the copper is not scattered over such a large area.

(6) Pathfinder Element — This is an element that is closely associated with the one being searched for, but it is more mobile or forms stronger anomalies or is easier or cheaper to test for than the element being searched for. For example, arsenic is often used as a pathfinder element for gold, and mercury is sometimes used as a pathfinder for base metal sulphide mineralization.

(7) Extractable Metal — This is the part of the total content of a metal in a sample that can be extracted by a given chemical treatment. You may see the terms "hot extractable" or "cold extractable" for example. Usually the simpler geochemical methods extract less metal.

(8) Total Heavy Metals (THM) — A popular geochemical method responds to several base metals including copper, lead, and zinc but is unable to distinguish between them. Results are reported as "total heavy metals". The advantage of this method is simplicity and low cost, and it will detect anomalies caused by several metals. Its disadvantage is that once you have found an anomaly you do not know which metal caused it.

(9) Soil Horizon — Natural weathering processes, if they act for a long enough time, break down rocks into soils. Soils usually consist of a number of layers or **horizons** which differ from each other in appearance, and chemical and physical properties.

From surface to bedrock, the major layers are the **A horizon** which is usually only a few centimetres thick. It is typically rich in organic matter but is often leached of mineral matter. Below this is the **B horizon** which can be very thick, often a metre or more. It usually accumulates some mineral matter carried down from the A horizon but it too may be leached of other mineral matter. Beneath this is the C **horizon** which is distinguished by containing partly weathered lumps and masses of bedrock or other parent material. Below the C horizon is unweathered bedrock or parent material.

This is a very simple description and it is possible to subdivide the A, B, and C horizons into several minor horizons, but this is a matter for the expert. Prospectors should note that there is usually an easily visible change in colour and texture at the boundary between the A horizon and the B horizon, and that soil geochemical tests are commonly run on samples from the top of the B horizon.

Glaciation, as mentioned previously, complicates geochemical methods. Generally, in most parts of British Columbia, soils have not had time to develop properly since the last glaciation and such soils as have developed are frequently on glacial deposits, not on bedrock. In many places the B horizon may be poorly developed or missing altogether. Soil geochemistry may still work if glacial cover is thin, a metre or two, but you can expect anomalies developed from any mineralized float in the glacial cover to be irregular and displaced down the direction of ice movement. Anomalies, developed in soils formed from the underlying bedrock on the other hand, are likely to be over the mineralization or displaced downslope. Anomalies behave in this respect much like mineralized float (*see* tracing of float in Chapter 11) except that they usually spread much farther from their source.

(10) pH — The pH is a measure of acidity. A pH of 7 is neutral, while 0 to 7 is acid and 7 to 14 is alkaline. The pH of stream waters and soils can greatly affect geochemical results because the pH affects the solubility and mobility of metals. You can usually avoid problems caused by pH differences by taking stream sediments only from freely running streams, and soil samples only from well-drained soils.

GEOCHEMICAL TESTS

A typical geochemical test involves a number of steps which will be described in outline form:

(1) Sample Preparation — Some treatment of the sample prior to testing is usually required. Soil and stream sediment samples may have to be dried and sieved to get the right size fraction for a test.

(2) Measurement of the Sample — This is usually done with a plastic or aluminum scoop, sized to contain the desired weight of sample.

(3) Chemical Attack — There are many possible forms of chemical attack but the one most commonly used is to add a solution, often an acid, to the sample. Plastic dispensers which will add the right amount of solution are often used. The attack usually takes place in a specially graduated test tube which is stoppered and shaken vigorously for a specified time.

(4) Buffering — The next step is to add a solution called a **buffer** which performs a number of tasks such as adjusting the pH of the mixture and preventing undesirable metals from interfering with the next step. In simpler procedures steps 3 and 4 may be combined using a single solution.

(5) Complex Formation — A sensitive reagent, usually dissolved in an organic solvent, is added next and the mixture shaken. The reagent reacts with the desired metal to form a coloured **complex** which remains dissolved in the organic solvent.

(6) Measurement — The amount of the desired metal present in the sample is then determined from the colour of the dissolved complex. This may be done with the aid of a colour chart or by comparing the colour to coloured plastic discs or to colours obtained by performing the test on a **standard solution** which contains a known concentration of the desired metal.

ACCURACY OF GEOCHEMICAL TESTS

Field geochemical tests are designed for speed, low cost, and performance under field conditions with simple equipment. Under these circumstances they cannot be expected to be very accurate. Commercial kits usually give an idea of the accuracy to be expected but do not be surprised if you see an accuracy of "plus or minus 50 per cent". Geochemical tests are not assays and the important point is the size and general strength of an anomaly, not the number of parts per million obtained for any particular sample.

You should consider the numbers you get as "ballpark" figures; do not get too excited over the odd very high result unless you can duplicate it by testing another measure or scoop of the same sample, or by getting high results from fill-in samples nearby.

AVAILABLE METHODS

The beginner should consider only the **Bloom Test (THM)** or the **Holman Test** for copper. Kits for these tests usually come as a complete package of all chemicals and hardware; there are also refill kits of chemicals only. Your District Geologist will be able to give you particulars of companies currently supplying these kits. "Recipes" for geochemical kits are occasionally available from books, journals, or other sources. Unfortunately such recipes are usually intended for the professional, and you should not attempt to make up your own kits.

TIPS ON USING A KIT

The first-time user of a geochemical kit should take note of the following general points. They will help you get the maximum value out of your kit and avoid possible disappointment.

(1) Follow the Instructions — Never attempt to change a procedure or vary it in any way. A common mistake is to attempt to save unused solutions for use next day when the instructions state that such solutions should be discarded. Made-up solutions often have a very short life and just cannot be saved.

(2) Cleanliness — As mentioned earlier geochemical tests are extremely sensitive and you must guard against contamination from dirty equipment and poor habits at all times. Extremely pure water called **deionized water** must be used to make up solutions and to wash out any glassware or equipment that was used in a test before starting the next test. Special plastic dispensers with a purifying cartridge are available to

provide such water. Some kits will specify a particular solution to be used for cleaning purposes. Take extra care to clean equipment after any test which gives a very high result otherwise you might contaminate the next test. Never touch any part of the equipment that comes in contact with the sample or test solutions with your fingers, no matter how clean you think they are.

(3) Smoking — Smoking while performing geochemical tests, even out in the open, must be avoided. The organic solvents used in most kits are *dangerously flammable*. Tobacco smoke and tobacco ash in particular contain traces of easily extracted metals.

(4) Heat and Light — Solutions of some chemicals commonly used in geochemical tests are quickly affected by both heat and light. Your kit will identify these solutions for you so try to keep them cool and out of direct sunlight at all times. An effective light barrier can be made by wrapping any bottles containing such solutions in aluminum kitchen foil.

(5) Record Keeping — Take care to record all sample locations and write down the result of each test before you move on to the next. Do not trust your memory!

(6) Practice — If you have not used a kit before, make up a batch of solutions and practice on some stream sediments or soils. A certain amount of dexterity is needed to get consistent results with a kit.

STREAM SEDIMENT GEOCHEMISTRY

The idea behind stream sediment geochemistry is straightforward. As weathering and erosion work away at an area containing mineralization, metals eventually find their way into the streams draining that area. Traces of metals can be detected in the stream waters themselves by using specialized techniques. Sometimes tiny particles of ore minerals may be found in the stream sediments, but more often very fine sediment particles in the streams absorb traces of metals on their surfaces from the stream water. These traces are easily extracted and measured.

PROCEDURE

In practice stream sediment geochemistry may be difficult work if the bush is heavy, or the slope is steep, and you can expect to get wet. There are a number of other points to watch for:

(1) The area drained by a stream and its tributaries, called the **drainage basin**, should have at most a thin cover of glacial deposits — the thinner the better. In such areas you should expect to see outcrops in or near the streams. Streams which appear to be entirely on or in glacial deposits are unlikely to give any usable results.

(2) Large streams or rivers should be avoided. Their drainage basins are too large and dispersions will probably be too diluted to detect. You should also avoid sluggish or stagnant waters, or streams that are in or have passed through marshy or swampy areas. The best streams or creeks are free running with very little or no aquatic vegetation in them.

(3) For reconnaissance work you should sample 2 to 4 times per kilometre of main stream and collect a sample about 20 metres upstream in every free-flowing tributary. Larger tributaries should be treated as another main stream.

(4) Samples should be taken from the **active stream**, which means where water is flowing, and away from banks where bank material may have fallen into the stream. Waterproof boots are therefore a "must".

(5) Fine silt only should be taken. Up to a point the finer the sediment the better, but clay or organic-rich mud will interfere with most tests; this is the reason for sampling free-flowing parts of creeks or streams.

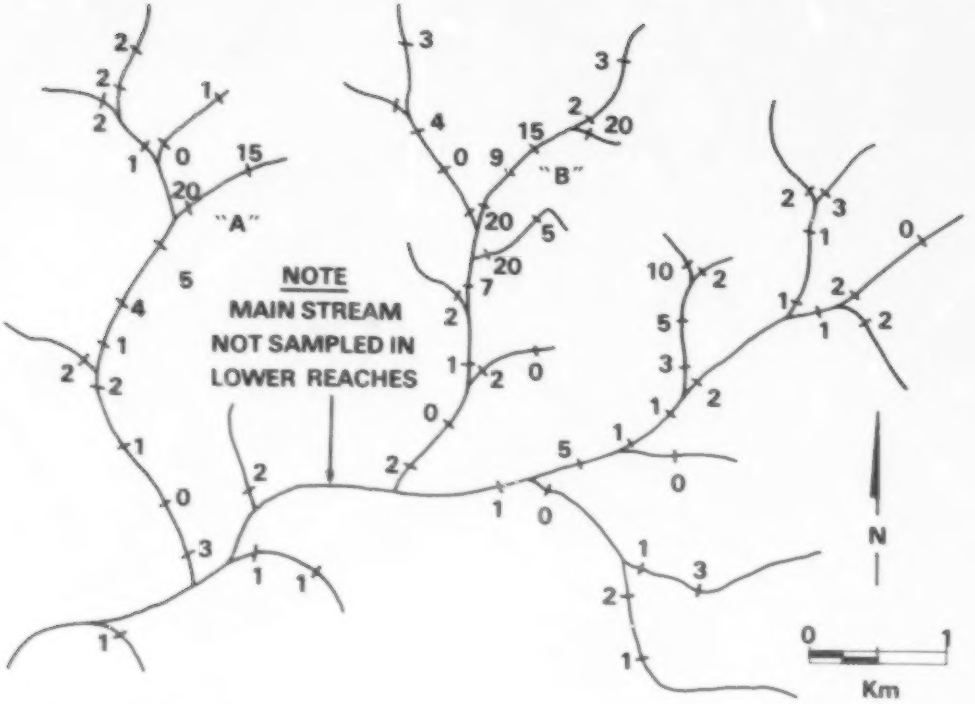
You may have to turn over rocks or dig in the stream bed to find fine sediment. The usual sample size is about 50 grams, but if you have trouble finding enough fine sediment you can always collect a larger sample containing mixed sizes and sieve it when dry. Suppliers of kits usually sell special paper sample bags and noncontaminating sieves for this purpose. The usual sieve size is "80 mesh" which means that only very fine sand or smaller will pass through it.

You should make up your sample with about 10-gram portions of sediment taken from five or six different spots at the sample location rather than taking it all from one spot. If you are doing your tests as you go, you can mix the sediment in an aluminum or polyethylene cup with your measuring spoon before doing the test, otherwise combine the portions in the sample bag and mix the material carefully when dry.

(6) Once you have located a promising anomaly you must then do a careful ground search of the drainage basin the anomaly is in. You might be able to narrow the search area further by doing fill-in stream sediment sampling at intervals of 50 to 100 metres on every creek, including very small creeks you might have ignored before. Figures 10-1 and 10-2 show how this might be done. You should note that very few companies are likely to want to sign a deal on the basis of a prospector's geochemical results alone until he or she has established a reputation for reliability. The beginner must find additional signs of mineralization.

GEOPHYSICAL PROSPECTING

The only geophysical method that will be described here is the use of the ultraviolet lamp. Some Additional Notes are included on other geophysical methods. These will give you a very brief outline of the methods and an indication of the types of mineralization that each method is usually used to search for. It is always interesting and sometimes valuable when reading assessment or other reports by mining or



COLD EXTRACTABLE COPPER IN PPM.

NOTE THAT THE RESULTS ARE MOSTLY IN THE RANGE 0 TO 5 PPM; YOU COULD CONSIDER THIS RANGE THE LIKELY BACKGROUND.

THERE ARE A COUPLE OF ANOMALOUS RESULTS IN AREA "A" AND SEVERAL IN AREA "B". CHECK AREA "B" FIRST.

Figure 10-1. Reconnaissance stream sediment geochemistry.

exploration companies to know what kind of mineralization they were looking for or hoped they might find in a particular area.

THE ULTRAVIOLET LAMP

Portable ultraviolet lamps are available in two basic types, **short wave and long wave**. More elaborate designs may be a combination short wave and long wave instrument and some have a built-in flashlight. They all work on the principle that certain minerals can absorb ultraviolet light energy and emit it as a visible light. This property is called **fluorescence**.

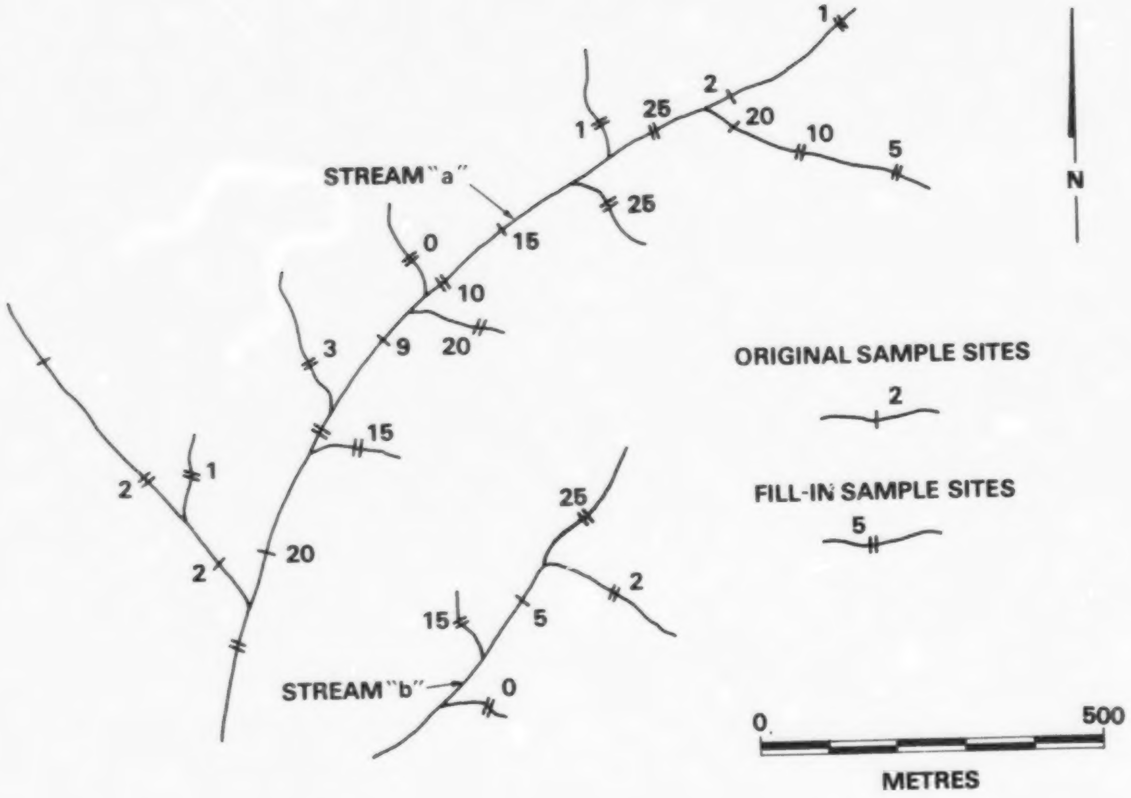
If you decide to purchase an ultraviolet lamp choose a short wave or a combination lamp, even though these are much more expensive than a simple long wave lamp. Long wave lamps are of limited value.

As a prospecting tool, the ultraviolet lamp is usually restricted in this province to the search for tungsten deposits using the fluorescence of **scheelite**, an important tungsten mineral. Scheelite is a pale yellowish or brownish white with a glassy lustre, a hardness of 5, and a density of 6. It can be mistaken for yellowish or brownish feldspar or opaque quartz and it is easily overlooked in the field. It fluoresces a strong bluish white in short wave ultraviolet light.

Many other minerals fluoresce — some only if they have the right kinds of impurities. While very few of these are ore minerals, the prospector should not overlook strongly fluorescent specimens because there can be a good market for these among mineral collectors and rock shops.

PROSPECTING WITH AN ULTRAVIOLET LAMP

There are three ways of prospecting with an ultraviolet lamp and all of them have serious drawbacks due to the fact that fluorescence can only be observed in dark or near-dark conditions. A drawback common to most portable lamps is that the batteries are usually expensive and they do not last long, in some types batteries may only last a few hours of



THE FILL-IN SAMPLING SHOWS THAT THE ANOMALOUS GROUND IS TO THE SOUTHWEST OF STREAM "a" AND PROBABLY TO THE NORTH AND NORTHWEST OF STREAM "b". THE AREA BETWEEN STREAMS "a" AND "b" SHOULD BE GIVEN A CAREFUL GROUND SEARCH.

IF ANY INTERESTING MINERALIZATION IS FOUND IN THIS AREA, THEN ANOMALOUS AREA "A" ON FIGURE 10-1 WOULD BE WORTH CHECKING.

IF YOU ARE DOING TESTS ON THE SPOT, THEN YOU CAN DO YOUR FILL-IN TESTING ON YOUR RETURN TRIPS DOWN EACH CREEK IF THE RESULTS ARE PROMISING.

Figure 10-2. "Fill in" stream sediment geochemistry — area B.

continuous use. Some units use rechargeable batteries, but the initial cost of these is much higher of course.

When checking specimens or outcrops *do not look directly into the lamp or at the light reflected off shiny surfaces*. The eyes are very sensitive to ultraviolet light and exposure may cause temporary discomfort or even permanent damage. Special protective goggles are available but many people find these uncomfortable to wear for any length of time.

(1) Prospecting at Night — Clearly, travelling in the bush or in rugged country at night is hazardous, even with the aid of a flashlight. It can be done, and it is done, but it should be confined to well-known areas such as trenches, or outcrops along roads or trails, or other areas that you know well and can reach safely by flashlight.

(2) Checking Specimens or Samples — The usual method is to check any specimens you have collected with a lamp at your camp or home. The disadvantages of this method are firstly that you may miss fluorescent specimens completely while collecting and, secondly, if you do find any fluorescent specimens in your collection you will have to make another trip back to the area you found them in to follow up the find.

(3) Using a Tarpaulin — This is an alternative to prospecting at night — you take the darkness with you. A piece of black plastic sheet about 3 or 4 metres square is draped over the outcrop area to be checked. The prospector crawls underneath and checks the rocks with the lamp.

In practice, care must be taken to exclude sufficient daylight for satisfactory results and you must repeat the procedure many times to check any sizeable outcrop area. Also you may have to wait a minute or two for your eyes to adjust to the dark. While you are waiting you will no doubt discover how remarkably hot this setup can be on a sunny day, and what an unbelievable attraction it makes for flies!

ADDITIONAL NOTES

OTHER GEOPHYSICAL METHODS

The Self-potential Method

This method depends on the fact that small voltages exist between any two points on the earth's surface. "Background" voltages normally range from a few millivolts (thousandths of a volt) to a few tens of millivolts. Anomalous negative voltages of a few hundred millivolts are sometimes found where sulphide mineralization is oxidizing. Anomalous voltages may also be caused by rocks containing graphite (a form of carbon) and by certain groundwater conditions.

Interpretation of results is straightforward: areas of anomalous negative voltages should be examined for the presence of sulphide mineralization.

The self-potential method is one of the few geophysical methods that might be considered by the experienced prospector as the key piece of equipment — a very sensitive portable voltmeter — can be purchased for about $100.00 at the time of writing. Other items, such as the electrodes used to make electrical contact with the ground, could be purchased for a few dollars or made by anyone with some elementary electrical knowledge.

Unfortunately conditions suitable for the self-potential method are not common in British Columbia or elsewhere in Canada. Metamorphic rocks especially may contain enough pyrite or graphite to give anomalies and even a thin cover of glacial till can act as an insulator so that mineralization is easily missed. Consequently very few companies bother with the method, with the result that those few situations where it could work are also missed.

The Magnetic Method

This method measures the strength of the earth's magnetic field and can be done on the ground or with airborne equipment. The strength is measured in a unit called the **gamma** (γ), and the earth's magnetic field is usually between 60 000 to 65 000 γ. The usual way to present magnetic data for an area is in the form of a contour map.

Local variations are caused by natural variations in the amount of magnetic minerals present in rocks. The most important of these are magnetite and pyrrhotite, and the magnetometer can be used to search for any mineralization containing these minerals.

The patterns on magnetic maps typically reflect the local geology, and the magnetic method is often used by mining and exploration companies to get an idea of the geology, especially in areas where outcrops are scarce.

Two types of magnetometer are available. The older and less accurate type is called a **fluxgate magnetometer**; it measures a part of the earth's magnetic field called the "vertical component". This instrument has now been almost completely replaced by the more accurate but more expensive **proton precession magnetometer**; it measures the total magnetic field. When using a magnetometer, great care must be taken to remove all magnetic metals from clothing or equipment that might come near the instrument; also, special procedures must be followed to allow for the fact that the earth's magnetic field varies or **drifts** throughout the day. Magnetometers cannot be used during occasional geophysical disturbances called **magnetic storms**.

The best way to try to interpret magnetic maps is to compare them side-by-side with geological maps of the same area. Geologists first try to explain areas of high readings in terms of rock types or structures and if this cannot be done satisfactorily then these areas are investigated.

Electrical Methods

The Resistivity Method — This method measures the resistance of near-surface rocks to the passage of an electrical current. The unit used to measure resistivity is the ohm (Ω), although it may be combined with other units for technical reasons.

Compared to most rocks, all sulphides except sphalerite are fair to good conductors of electricity, hence areas containing massive or disseminated sulphides should show up as having low resistivity.

Unfortunately many other things in nature conduct electricity besides sulphides including some rocks, especially those containing graphite, some highly porous water-saturated rocks, water-saturated faults, shear zones or fissures, and some soils. For this reason resistivity surveys are rarely used on their own in exploration.

The usual method requires a line of four electrodes driven into the ground. A current is passed through one pair of electrodes and the voltage is measured at the other pair. A formula is then used to calculate the resistivity. By moving the four electrodes around, a resistivity map can be prepared.

Induced Polarization (I.P.) Method — This method measures various electrical responses to the passage of alternating currents of different frequencies through near-surface rocks or to the passage of pulses of electricity.

The method was developed and refined to detect disseminated sulphide mineralization and it has been used in British

Columbia with success in the search for porphyry deposits. It also responds well to massive sulphide mineralization and consequently it is a very popular geophysical method. Unfortunately the theory behind the method is very complex, the equipment used is expensive, and interpretation of the results requires some technical knowledge. In addition to sulphide mineralization, anomalies can be caused by rocks containing graphite or magnetite, certain clays, and mica.

The setup used is similar to that for a resistivity survey and the resistivity must be determined in order to calculate induced polarization results. Two induced polarization methods are used and they are usually done with the same equipment. In the **frequency domain method** the resistivity is determined at two different frequencies and the numbers are processed into a quantity called the per cent frequency effect. Contour maps of the per cent frequency effect are then prepared and areas of anomalous frequency effect are investigated. In the **time domain method** a pulse of current is passed through one pair of electrodes and the ground retains some of the energy in the form of an electrical charge, rather like a poor battery. The length of time the ground retains the charge is measured at the other pair of electrodes in milliseconds (thousandths of a second). The results are expressed as a contour map or as a series of cross-sections. Areas that have a high chargeability, meaning that they can retain a charge for a long time, a few tens of milliseconds to over a hundred milliseconds, are then investigated.

Electromagnetic Methods

There are many electromagnetic methods. All of them require an electromagnetic field such as radio waves from special radio stations or a field from a transmitting coil. This field is called the **primary field**.

Normally the primary field dies out as it penetrates the earth, but if there is a conducting zone near the surface the primary field will cause currents to flow in the zone. These currents then cause a **secondary electromagnetic field** that can be detected by a special receiver, usually as a change or distortion of the primary field.

Electromagnetic methods work on the ground or can be airborne. They can detect shallow massive sulphide mineralization. Sulphide grains must be touching to be a conductor for these methods so they cannot be used to search for disseminated sulphides. Anomalies are also caused by rocks containing graphite and sometimes certain clays, and by conducting faults, fractures, or shear zones. These in fact account for the great majority of anomalies. Generally the simpler methods will only penetrate about 8 to 10 metres and thus cannot be used in areas of deep overburden. More expensive and more complex equipment can penetrate to depths of 30 to 100 metres.

The Very Low Frequency (V.L.F.) Method — This is the only electromagnetic method that will be mentioned in more detail, as its use could be considered by an experienced prospector, and the results are easier to interpret than for most other electromagnetic methods.

The primary field is provided by very powerful transmitters set up around the world for communication with submarines and for other military purposes. At least two or three transmitters are suitable for use in British Columbia, and most units can select the desired transmitter by means of a switch. The secondary field appears as a change or **tilt** in the direction of the primary field, and a change in the **field strength** when passing over a conducting zone.

The conducting zone should be at least 30 metres long and no deeper than 20 to 30 metres. The strike of the conducting zone should be the same as the direction to the transmitter. As the angle between the two directions increases, the response from the conductor becomes poorer and if it exceeds 40 to 50 degrees another transmitter should be tried.

The results are usually plotted on a series of cross-sections. Conducting zones occur where there is a rapid change from positive to negative tilt, and a coincident marked increase in field strength.

The Seismic Method

The seismic method uses shock waves generated by a hammering device or a small explosive charge. These shock waves travel through rocks at several thousand metres per second and contacts between different rock types usually reflect back some of the shock wave energy to recording devices at the surface. By measuring the time it takes for these reflections to reach the surface and knowing the speed of the shock waves in different types of rock or overburden, it is possible to calculate the depth of the contact.

The seismic method is rarely used in mineral exploration. It is sometimes used to determine the depth of overburden, and it has been used in attempts to locate buried river channels in placer prospecting.

Radiometric Methods

Radiometric methods measure radioactivity. Natural radioactivity is caused by cosmic rays, uranium and thorium mineralization, and rocks containing potassium minerals such as the potash feldspars and muscovite mica. Of the various radioactive particles and rays, most instruments detect gamma rays, which are similar to X-rays.

The cheapest and simplest instrument, and the least useful, is the **geiger counter** which uses a special type of vacuum tube as the detecting device. A more sensitive instrument called a **scintillometer** converts the rays into a flash of light inside a detecting crystal and measures the intensity of the light flash. The most expensive instrument is a special type of scintillometer called a **spectrometer**. This instrument can tell whether the radioactivity is due to uranium, thorium, or potassium, and some can give an approximate analysis of the amount present in the rocks being tested.

The radiometric method is rarely used in British Columbia. This is partly due to the fact that overburden absorbs radiation which makes the method virtually useless in areas of thick overburden, but mostly it is due to the current moratorium on exploration for radioactive deposits in British Columbia. Nevertheless other types of mineral deposits, such as phosphate deposits and carbonatite deposits, may contain traces of radioactive minerals and a scintillometer or spectrometer could be of use in prospecting or exploration for such deposits.

CHAPTER 11 — PLACER DEPOSITS

INTRODUCTION

A placer deposit consists of some valuable mineral that accumulates in weathered rock or overburden (eluvial placers), in stream sediments (alluvial placers), or in beach deposits (beach placers) as a result of natural weathering and erosion processes. In British Columbia only alluvial gold and, in a few places, platinum-bearing placers are important, but in other parts of the world, eluvial, alluvial, or beach placers containing diamonds, tin, titanium, rare earth, or radioactive minerals are also important.

Placer gold attracts people and the working of placer leases, either as a commercial endeavour or as a recreational pursuit, is a major activity in the province involving between two and three thousand people and expenditures of over $15 million per year for the last few years.

MINERALS FOUND IN PLACER DEPOSITS

Minerals that can survive weathering and erosion must be resistant to chemical and mechanical breakdown. They are generally hard and lack cleavage. To accumulate in placer deposits they must also have a high density. Gold differs from most placer minerals in being quite soft, but it resists mechanical breakdown by deforming rather than breaking. The density of gold is also exceptional, ranging from 14 to 19.5 depending on impurities. This is over twice that of most other placer minerals.

Most of the common minerals found in placers are of no value in themselves, other than as indications that placer-forming processes have occurred. There will always be some of the lower density resistant minerals such as quartz and garnet present in placer deposits. The most common higher density minerals present are magnetite and ilmenite (black iron-titanium oxide). These are the major constituents of **black sands**. Less commonly you will find such minerals as scheelite, pyrite, other sulphide minerals, native silver, native platinum, and hopefully native gold.

FORMATION OF PLACER DEPOSITS

The processes that lead to the formation of alluvial placers are relatively simple, but it may be very difficult to recognize or trace these processes in the field. Most experts in fact would agree that the average placer deposit in the province has had a long and complicated history and what may be true for one placer deposit may not be true for another in the same drainage basin or even along the same creek. Two factors which complicate the history in British Columbia are glaciation and previous mining activity. These will be considered briefly later.

First, there must be gold mineralization in the area drained by a stream and its tributaries. It need not be high-grade mineralization nor, as is often thought, must it outcrop in or near the stream beds. Weathering breaks down the gold-bearing mineralization with a mixture of chemical and mechanical processes and releases the gold into the overburden. Once liberated in this way a variety of erosion processes cause the overburden and the gold to move slowly downhill or **creep** to the nearest creek. In British Columbia, as in most of Canada, freezing and thawing effects on a daily or seasonal basis are very important in breaking up gold-bearing mineralization and causing the overburden to creep downhill. Figure 11-1 shows a vein containing a low-density mineral (quartz), a high-density mineral (pyrite), and a very high-density mineral (gold). As the vein weathers and breaks up and the overburden slowly creeps down-slope, there is usually some separation of the vein material by density, with some quartz float making its way to the surface sooner than the pyrite float, while the free gold may not make it to the surface at all. Generally the fragments of float become smaller down-slope but they remain essentially irregular and angular (Fig. 11-2).

The preceding is a useful guide for tracing float of any mineralization, not just gold, up-slope to its source.

IN-STREAM PROCESSES

Once in the creek, the carrying power of running water and the wearing action of sediment moved by the water take over. Figure 11-3 shows a cross-section of a stream, with the gold assumed to be uniformly scattered throughout the stream sediments. The sediment when it is in motion is called the stream **load**. Part of the load is the familiar sediment stirred up by the turbulence of the moving water. This is called the **suspended load**. There is also the less familiar but equally important **bed load**, which consists of coarser sediments such as gravel and pebbles skipping, rolling, or sliding along the stream bed.

Gold is so dense and settles through clear water so quickly that it is very difficult for it to be moved by a stream. As a result the gold becomes concentrated because it is left behind when other sediments are removed downstream. Most of this concentration action takes place in times of flood when the stream can stir up and move a lot of bed and suspended load, allowing the gold to settle closer to the bedrock. Figure 11-4 shows the situation after a flood. The gold in the upper part of the bed settled down to the level disturbed by the flood and was covered by sediment brought in from upstream.

Figure 11-5 shows the situation after a particularly severe flood — the kind that may occur only once in a hundred or a thousand years. Here the sediment has been disturbed right down to bedrock and most of the gold has now made its way onto or close to bedrock where it is usually mixed with the largest and hardest-to-move boulders.

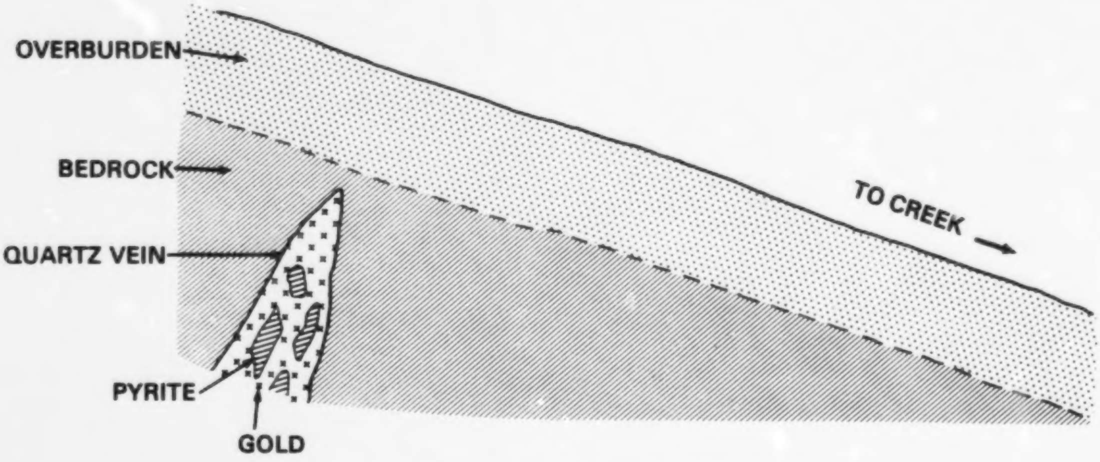


Figure 11-1. Vein near surface.

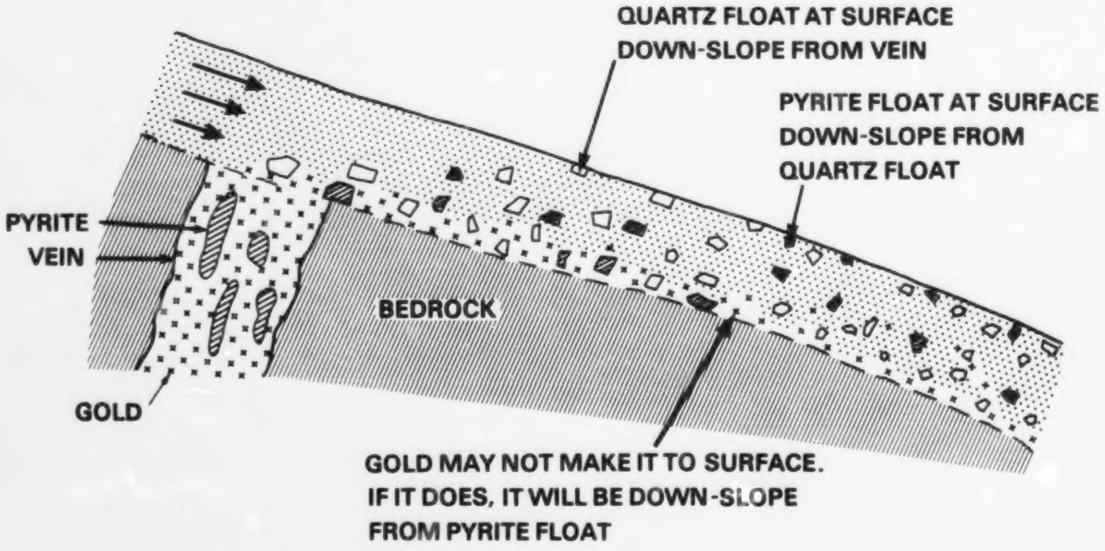

QUARTZ FLOAT AT SURFACE DOWN-SLOPE FROM VEIN
PYRITE FLOAT AT SURFACE DOWN-SLOPE FROM QUARTZ FLOAT
PYRITE
VEIN
BEDROCK
GOLD
GOLD MAY NOT MAKE IT TO SURFACE. IF IT DOES, IT WILL BE DOWN-SLOPE FROM PYRITE FLOAT

Figure 11-2. Vein being weathered and overburden "creeping" down-slope.

Thus each flood acts to sort out and remove some of the sediment but to allow most of the gold it contained to settle deeper, thus over many, many years, as overburden containing some gold is continually supplied to the creeks, the concentration of gold slowly builds up. Figure 11-6 shows such a situation after many floods, both moderate and severe. Most of the gold can be expected to be in so-called **pay streaks** on or close to bedrock, while in this example some has accumulated on a **false bottom** above bedrock. Hard-packed clays and silts, that may be very difficult for a stream to break up, even during floods, may act as efficient false bottoms and trap substantial amounts of gold to create worthwhile pay streaks above bedrock. The rest of the sediments in the stream bed can be expected to have some gold values too, especially the smaller sized particles but these may or may not be economic to work.

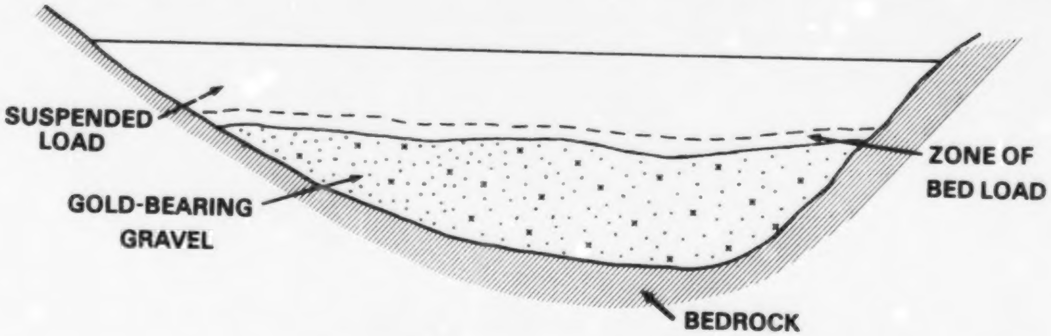


Figure 11-3. Development of a placer deposit.

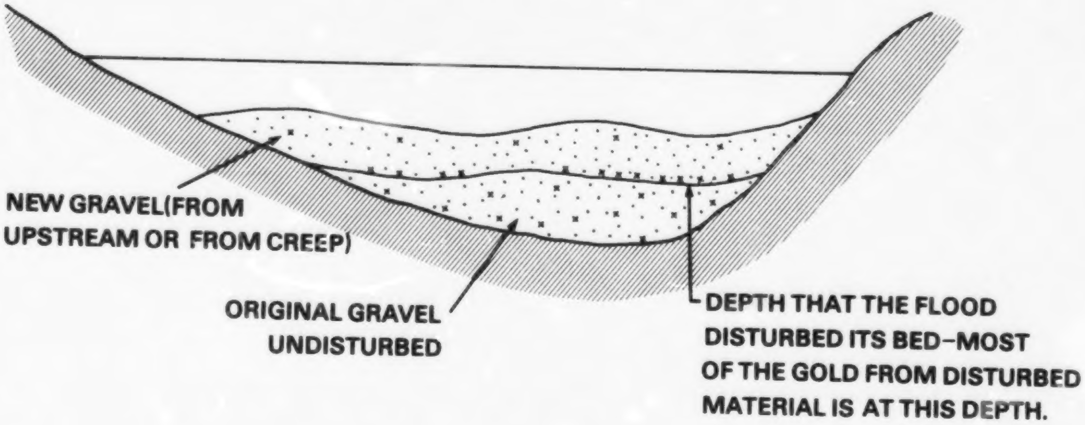

NEW GRAVEL(FROM UPSTREAM OR FROM CREEP)
ORIGINAL GRAVEL UNDISTURBED
DEPTH THAT THE FLOOD DISTURBED ITS BED-MOST OF THE GOLD FROM DISTURBED MATERIAL IS AT THIS DEPTH.

Figure 11-4. After a moderate flood.

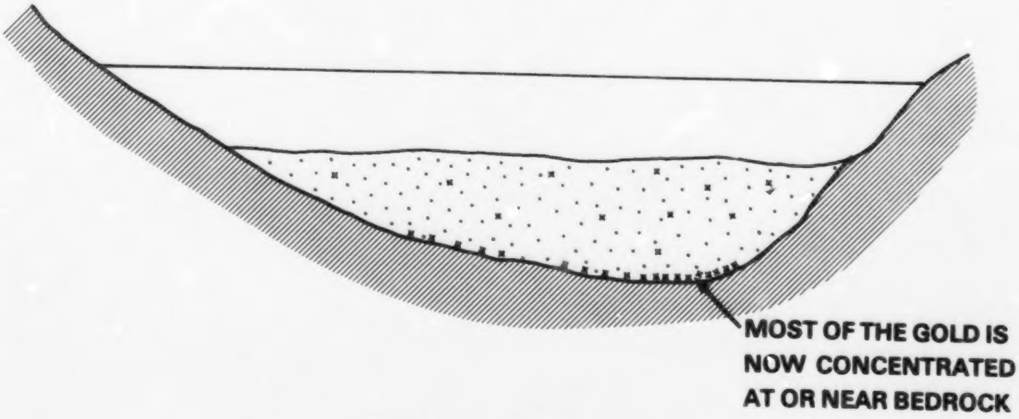


Figure 11-5. After a severe flood.

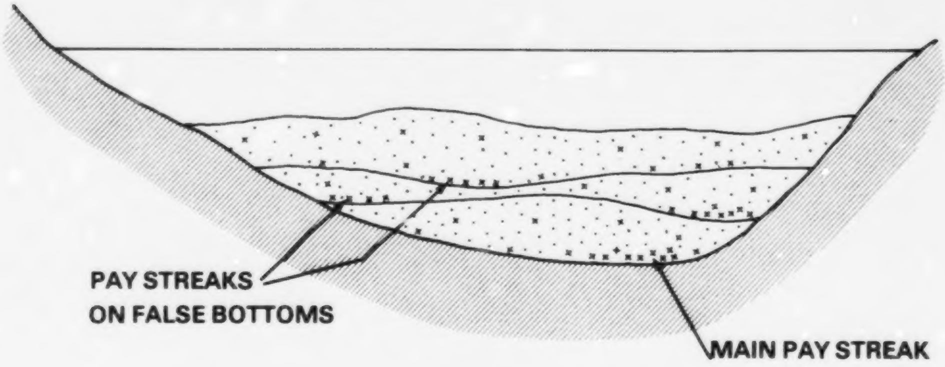


Figure 11-6. After several severe floods and some moderate floods.

DOWN-STREAM PROCESSES

Gold in placers also moves downstream, for a variety of reasons:

(1) Particularly violent floods may have the carrying power to clean out a stream channel and move everything, including gold, downstream.

(2) If flood waters become very heavily loaded with sediments, gold particles, once stirred into the load, may have difficulty settling through the sediment and thus be carried downstream.

(3) The grinding and wearing action of the bed load wears gold particles down or breaks them into smaller fragments, thus making them easier to move.

(4) Once small enough, a particle of gold may be carried in the bed load or suspended load for considerable distances.

There are other changes that take place downstream too. Angular fragments of gold become rounded. It is usually assumed that some rounding of sharp edges will have occurred after 1 kilometre of travel and complete rounding of edges after 5 kilometres or more of travel.

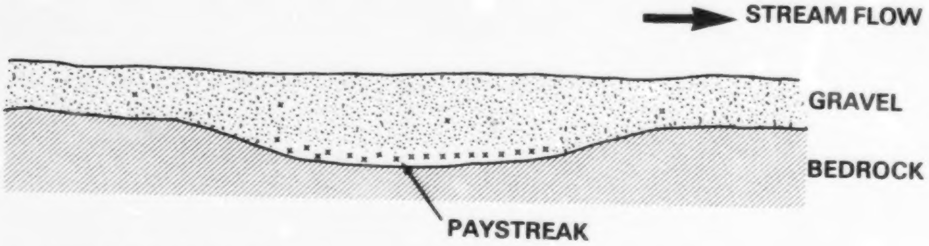
As gold fragments become smaller they tend to become flatter and by the time fragments have been reduced to say less than 0.1 millimetre in size, they may be very thin indeed. Such flake-like fragments of fine gold settle much more slowly in water. Thus they may be carried far downstream and occur dispersed through gravels rather than on bottoms. Eventually these tiny flakes break up into almost microscopic grains, the so-called **flour gold**. Flour gold will settle only in comparatively quiet water and may even float on a water surface.

It is not uncommon for quite impressive-looking amounts of flour gold to be found on sand or mud bars at times of low water. These are often called **skim bars** or **flood bars**. Not only does this gold create a totally false impression of the value of the gravel beneath but it is almost impossible to recover by customary methods of working placers. Occasionally, if the situation is just right, moss growing on rocks just above normal water level may trap flour gold during times of flood. Unlike skim bars this **moss gold** can be recovered by harvesting the moss, which will grow again, then drying and burning it. Some of the old-timers managed to make a living doing this.

Chemical changes also take place as the gold is moved downstream. Native gold usually contains between 5 and 25 per cent of impurities, chiefly silver, iron, and copper. Over time the silver and other impurities are leached out of the surface of a gold particle so that it actually becomes purer downstream. The surfaces of the gold particles become rougher as a result and placer gold never looks as smooth or as bright and shiny as vein gold. There is some evidence that under the right conditions gold in placers may chemically dissolve and precipitate on larger gold particles. This is a proposed explanation for the formation of the spectacular-sized nuggets for which some placers are famous.

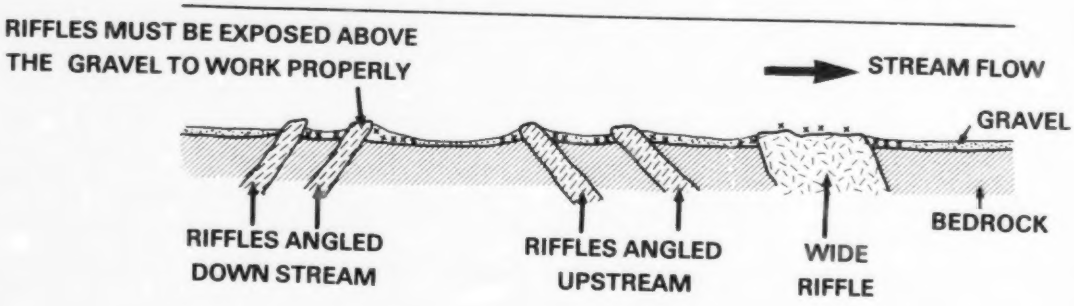
PAYSTREAKS AND TRAPS

In general, concentrations of gold will occur on bedrock or false bottoms for the reasons stated earlier and they can be expected either where water speeds slow, allowing gold in suspended or bed load to settle, or where bed load particles can be trapped. A number of such situations are illustrated on the following diagrams (Figs. 11-7 to 11-18).



NOTE : NATURAL POTHOLES ARE VERY POOR TRAPS DUE TO THE INTENSE GRINDING ACTION THAT TAKES PLACE IN THEM

Figure 11-7. Paystreak in a natural hollow.


RIFFLES MUST BE EXPOSED ABOVE THE GRAVEL TO WORK PROPERLY
STREAM FLOW
GRAVEL
BEDROCK
RIFFLES ANGLED DOWN STREAM
RIFFLES ANGLED UPSTREAM
WIDE RIFFLE

NOTE : RIFFLES PARALLEL TO STREAM FLOW OFTEN TRAP GOLD IF CLOSELY SPACED.

Figure 11-8. Natural riffles (resistant beds, veins, etc.).

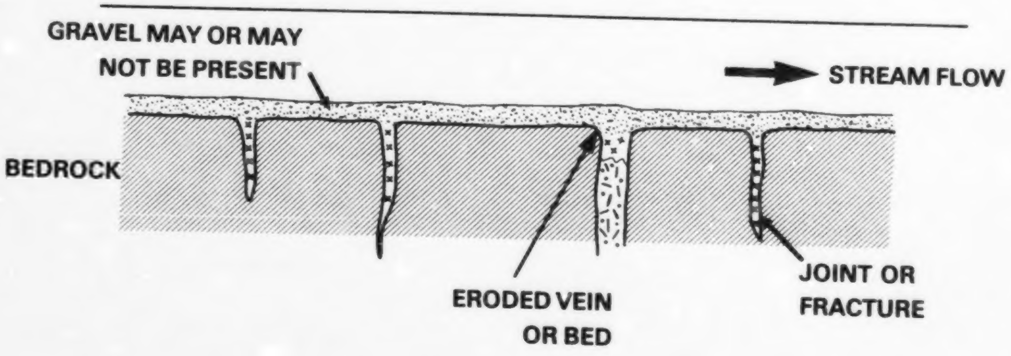


Figure 11-9. Joints and fractures in bedrock.

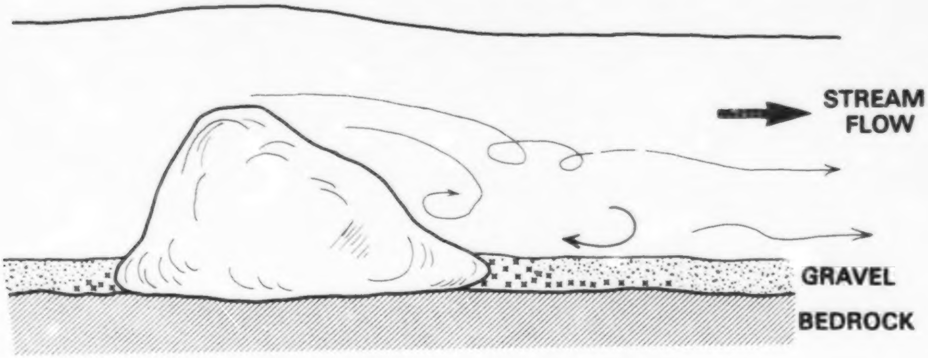


Figure 11-10a. Large rocks (section).

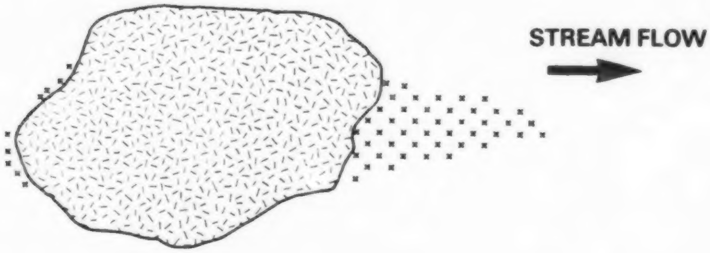


Figure 11-10b. Large rocks (plan or top view).

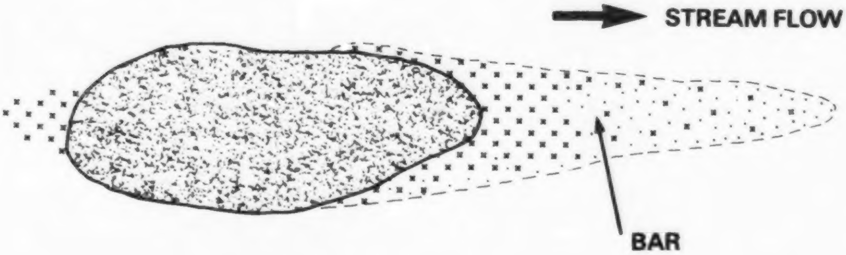
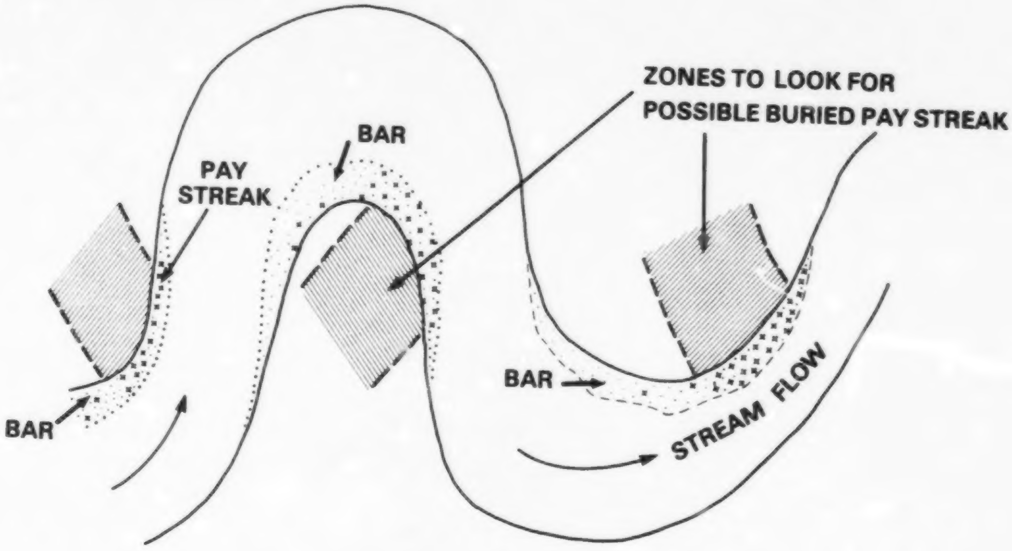


Figure 11-11. Islands (similar effect to large rocks).



NOTE : MEANDERING STREAMS SHIFT COURSE OVER TIME, AND MAY LEAVE BURIED PAY STREAKS AS SHOWN

Figure 11-12. Bars.

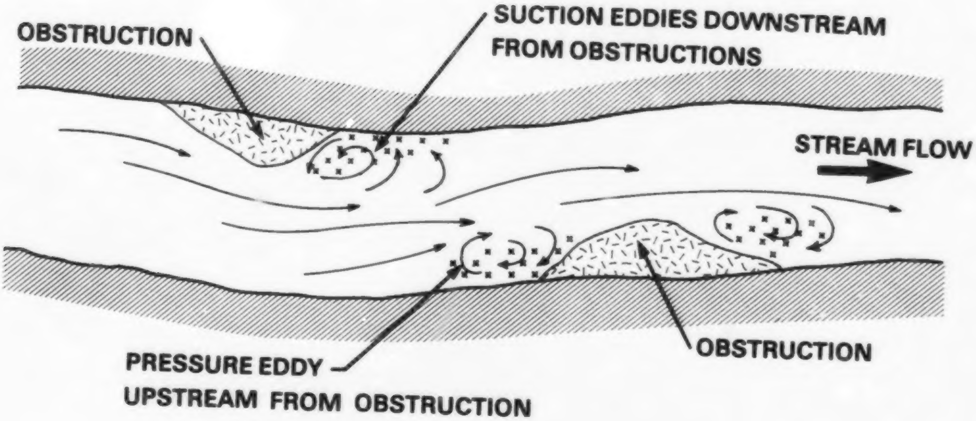


Figure 11-13. The concentrating effect of eddies.

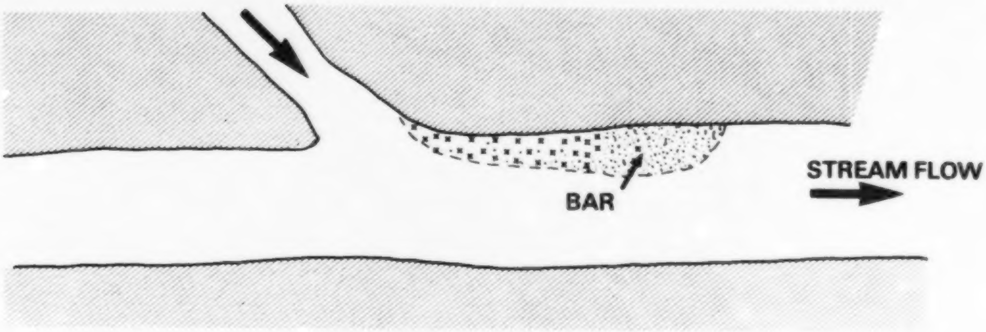


Figure 11-14. Fast-flowing tributary entering slow-moving main stream.

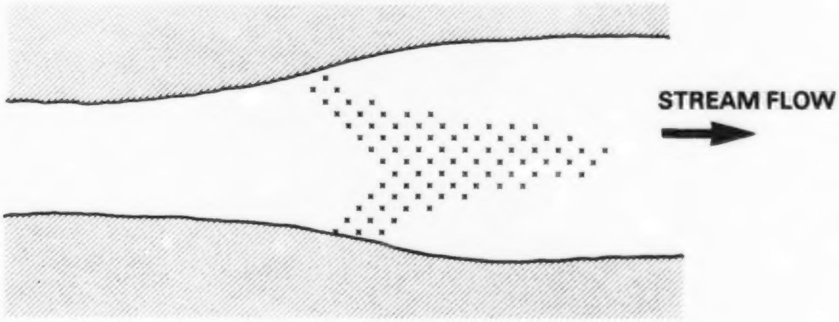


Figure 11-15. Stream widening (plan).

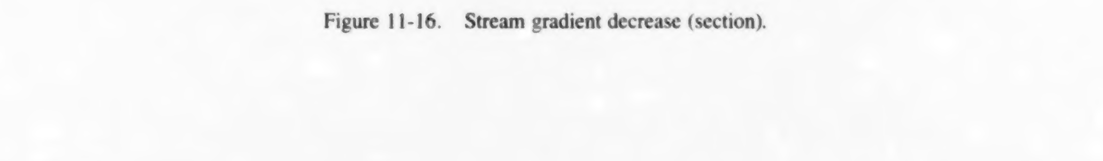
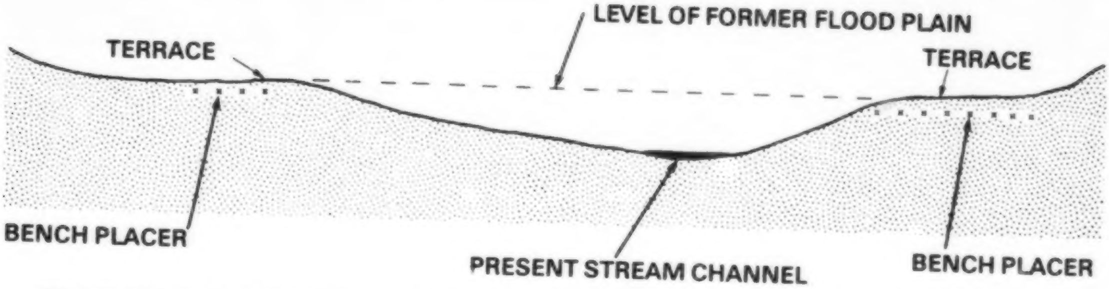
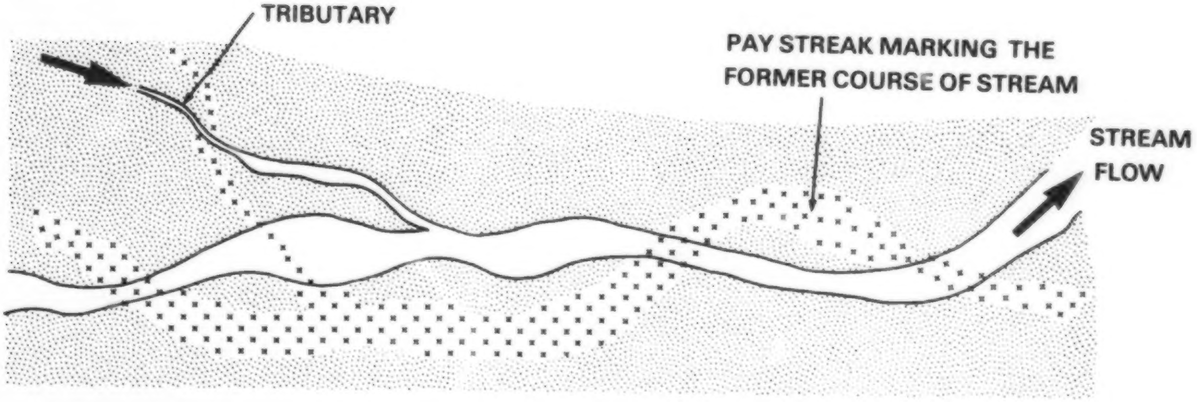


Figure 11-16. Stream gradient decrease (section).



TERRACES ARE THE REMAINS OF AN OLD FLOODPLAIN, AND PAY STREAKS MAY HAVE BEEN FORMED WHEN THE STREAM WAS AT THIS LEVEL. THESE TERRACE PAY STREAKS ARE USUALLY CALLED "BENCH PLACERS".

Figure 11-17. Placer gold in terraces (section across stream).



STREAMS USUALLY SHIFT THEIR COURSES FREQUENTLY WITHIN A VALLEY OR A FLOODPLAIN. THE LOCATION OF PAY STREAKS MAY NOT COINCIDE WITH THE PRESENT-DAY STREAM CHANNELS.

Figure 11-18. Old river channels.

GENERALIZATIONS ON ALLUVIAL PLACERS

The following generalizations about placer deposits can be made as a result of the information given so far and from many studies that have been made on placer geology. Remember that these are generalizations and there will always be exceptions.

(1) Placer deposits are usually found in country with rounded hills and fairly open valleys. In mountainous country, streams often have the carrying power to prevent alluvium and gold from accumulating; however, streams rarely have enough power to move gold other than flour gold far out into flat country.

(2) Placer gold is normally accompanied by other dense resistant minerals.

(3) There may or may not be any bedrock gold mineralization left in a placer gold area.

(4) Placer gold particles become smaller in size and purer the further they are from their source.

(5) Within a creek, gold is likely to be coarser where the gradients are steeper.

(6) Coarse gold and nuggets are usually found with coarser sediments such as pebbles and boulders, while finer gold is usually found with finer sediments such as gravels and sands.

(7) Coarse gold and nuggets are more likely to be found on or near bedrock or on false bottoms, while fine gold may be more dispersed.

(8) Gold in narrow valleys is more likely to be coarse and more likely to be right on the bedrock.

(9) Streams running over smooth bedrock or which have very little alluvium in them are unlikely to contain much gold, unless there are natural traps or riffles as outlined earlier.

THE ROLE OF MAN

It is commonly stated that all the creeks in British Columbia that contain gold have already been discovered, and that if the values are or were any good they have already been worked, perhaps many times, since their discovery. While there is considerable truth in this statement, it is obvious from the present high level of placer mining that the province's placers have not been worked either systematically or completely. Basically the rising price of gold and improved technology have made it possible to work ground that would have been uneconomic or impossible to work in the past.

There are several other factors that account for gold being left behind by previous operators:

(1) Greed — The old miner is depicted as greedy, working only the very best pay streaks and ignoring a lot of poorer ground. To be fair, if the cost of basic necessities in those old gold rush camps is compared to the price of gold at the time, it can be seen that the pay streaks had to be rich. Translated into today's prices there would be few streams indeed being worked now if bread were $15.00 a loaf and eggs were $20.00 each!

(2) Lack of Knowledge of Placer Geology — This was a major factor in the old days, and there is also a surprising lack of basic knowledge among many of today's placer miners.

(3) Lack of Interest in Fine Gold — It was widely believed that fine gold in a placer deposit represented only a minor amount of the total value of the gold and was not worth worrying about. This view is still held by many placer miners today even though it can be demonstrated that fine gold may represent 50 per cent or more of the total value of a deposit.

(4) Equipment Limitations — Equipment to move overburden or deal with difficult situations like the removal of large boulders was generally not available.

(5) Water Problems — The old miner lacked the knowledge and equipment to work much below the water table or to handle serious water problems.

To offset these factors there was a general lack of environmental concern or regulations, labour was usually cheap, and many placers were worked very thoroughly and often with great ingenuity, especially by the Chinese.

The net effect of past human activity is usually to make values in individual placer streams very unpredictable, since generally no maps were made nor records kept. If very clean gravels are found, with little or no clay or silt content, they have almost certainly been worked before. It is therefore vital that placer deposits be sampled properly before any large-scale mining operation is started.

EFFECTS OF GLACIATION

The effects of glaciation on the topography in general and on placer deposits in particular will be considered briefly. Moving ice has tremendous eroding and carrying power and any placer deposit disturbed by moving ice is likely to be dispersed and the gold mixed in with the rest of the glacier's load.

In the last few million years most of British Columbia was covered probably by four major ice advances separated by three warm or "interglacial" periods during which the ice melted or "retreated" almost completely. The major directions of ice movement during the last ice advance are shown on Figure 11-19. During the build up and retreat the ice directions were greatly affected by local topography and also by local glaciers or ice caps from areas of high ground, such as the Cariboo Mountains.

Generally if the ice moved along a placer valley the gold and everything else is likely to have been cleaned out and dispersed. If the ice direction was at right angles to the placer valley, then the valley might have been filled with stagnant ice or glacial load which protected the placer from ice erosion. Thus the placer might have been substantially unaffected or it could be buried under glacial deposits.

When the ice melts the debris in it is dumped as a blanket of **glacial till** over the countryside. Till consists of a jumble of sizes from large boulders to the finest clay. Pebbles are rounded and boulders may have a characteristic shape with flat faces and rounded edges (*see* Fig. 11-20). Mineralized float or gold particles in till must be traced by following back along the local ice direction, which is usually different from the local slope direction. Ice directions can often be spotted on air photos and sometimes on topographic maps. Your District Geologist will probably be able to give you this information for specific areas or tell you what to look for.

During ice advance and retreat, local drainages are badly disrupted by ice dams or by glacial debris. Sometimes old channels are blocked and new ones followed, but usually the old drainage patterns re-establish themselves as the ice retreats. In some places gold dispersed in glacial deposits is now being reconcentrated into placer deposits. Generally, however, there has been too little time since the last ice retreat for very much concentrating action and such placers are usually rather erratic, and of poor quality. The prospector should always be on the lookout for an old or buried river channel; recently several placer operations have started up on such so-called **Tertiary channels** — river channels that existed before glaciation but have been abandoned or buried

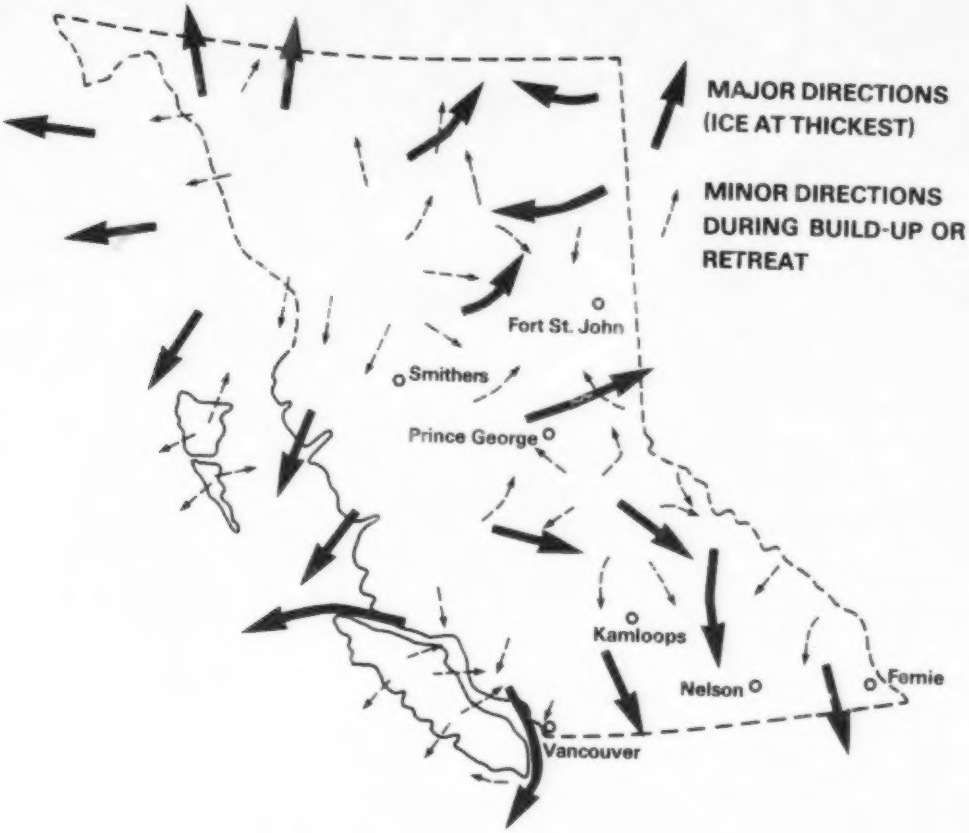

MAJOR DIRECTIONS (ICE AT THICKEST)
MINOR DIRECTIONS DURING BUILD-UP OR RETREAT
Fort St. John
Smithers
Prince George
Kamloops
Nelson
Fernie
Vancouver

Figure 11-19. General directions of ice movement in B.C.

as a result of glaciation. Since valley bottoms in most Designated Placer areas are currently heavily staked, old channels or benches may be the best prospecting bets.

SAMPLING OF PLACER DEPOSITS

The mistake most commonly made by placer miners is improper sampling of their leases. Some operations have even started with no sampling or testing at all! Only a few general comments on the subject will be given here, and professional advice should be obtained if any sizeable investment in operating a placer lease is contemplated. Because of their complexity, placer deposits are the most difficult mineral deposits of all to sample, and not every geologist or engineering geologist has the knowledge or experience to advise on placer sampling. Check on these points before you engage a consultant and do not be afraid to ask for references. Having engaged a consultant be prepared to pay for his or her experience and for what may seem to be a very costly recommended program of sampling; it will cost you more if you go bankrupt!

HINTS ON SAMPLING

(1) If there are not too many large boulders present, or if the gold values are thought to be fairly uniformly distributed, the usual procedure is to put in a series of test pits on a systematic grid pattern (*see* Additional Notes-3).

(2) The less uniform the ground appears to be the closer the grid spacing must be.

(3) If the ground is highly variable, or if there are a large number of boulders present, or if values are likely to be in a narrow buried channel which might be missed by a series of test pits, the usual procedure is to put in a series of trenches across the expected direction of any old channels (*see* Additional Notes-4).

(4) The pits or trenches should be dug to the expected depth of mining or to bedrock, whichever is less. This may require support or shoring and should be done by experienced workers. It is unwise to dig shallow pits, then assume that deeper ground will be of the same grade or richer; it could be poorer!

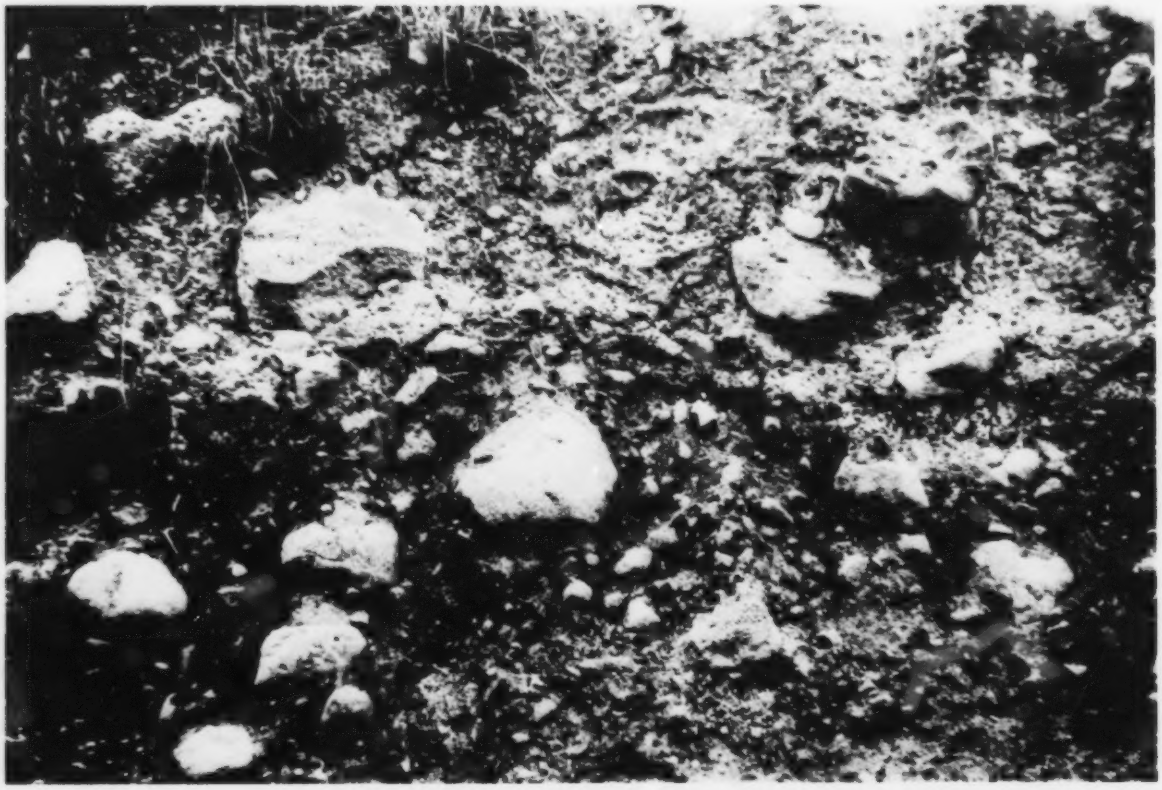


Figure 11-20. Glacial till.

(5) Each pit should yield at least a cubic metre of gravel and each trench should yield several cubic metres of gravel. The amount of gravel removed for each sample should be measured or estimated as accurately as possible. Boulders encountered in any pit or trench must be included in the sample volume estimate.

(6) Gravel from deep test pits should be broken up into different samples at any major change in ground to give some idea of how the values are distributed with depth or in different types of material.

(7) Gravel from trenches should be broken into several samples each representing a few metres of trench for the same reasons.

(8) The sampling should cover the ground you expect to work in at least one field season and the total volume of all samples taken should be related to the scale of mining you are planning. A rule-of-thumb often followed is that the total volume of all samples should equal not less than one day's production. Thus if you intend mining at the rate of 100 cubic metres a day your total volume of samples should be at least 100 cubic metres, and so on.

(9) The amount of gold in each sample should be determined by some small-scale mechanical method. A small sluice with hand-panning clean-up should be satisfactory.

(10) Nuggets should be separated and weighed but it is usual practice not to include nugget weights in calculations of gravel grades (the "nugget effect"!).

(11) Non-nugget gold can be carefully weighed on a gold balance or analytical balance.

(12) Never reduce the size of the test pit or trench samples and send them to a laboratory for fire or chemical assay. Fire assays in particular report all types of gold present including gold in sulphide minerals, flour gold, or specks of gold in larger particles; these may not be recoverable by a mechanical operation.

(13) The treatment of results from a series of test pits or trenches is explained in Additional Notes 3 and 4.

ADDITIONAL NOTES

1. USING THE GOLD PAN

Introduction

The gold pan is a valuable but somewhat neglected tool. Its use should not be confined to the search for gold in stream gravels. Traces of sulphides and other heavy minerals can be concentrated in a gold pan and can be useful guides to the presence of mineralization in the immediate area. Many other materials that are loose or easily crushed can also be panned including soils that are relatively free of clay, gossans, vein or other mineralization, and even crushed rock.

Figure 11-21. Cross section of the traditional gold pan.

Design of Gold Pan

The traditional gold pan is circular and stamped or "spun" from sheet steel (Fig. 11-21). This design is still commonly available in various sizes, in defiance of over 100 years of technological progress that should have made it obsolete.

Modern gold pans are made of metal, plastic, or sometimes fibreglass and have **riffles** in the design. Riffles are grooves, channels or built-in ridges designed to trap heavy minerals (Fig. 11-22).

The beginner should use a modern design with a simple pattern of riffles. It is much easier and quicker to use than the traditional type and requires considerably less practice to obtain good results.

Metal or Plastic?

This is a matter of personal preference. Steel pans are notorious for rusting unless carefully dried immediately after use. Some prospectors oxidize or "blue" the steel by heating it with a propane torch or in a hot fire. This bluish coating resists rusting and makes it easier to spot colours. Steel pans are very durable and you can crush softer rocks or gossans directly in the pan with your hammer.

Plastic pans are lighter but not as durable and can wear or crack with extensive use. They come in different colors; the dark or black pans make it easy to spot colours, but difficult to see black sand. Grey is a useful all-purpose colour. You can also remove magnetite in a concentrate directly from a plastic pan with a magnet which you cannot do from a steel pan.

How to Use a Gold Pan

There is no "correct" way to use a gold pan. Panning involves a number of basic operations:

(1) Breaking up lumps and washing out mud or clay.
(2) Removal of rocks and coarse gravel.
(3) Allowing the gold and other heavy minerals to settle.
(4) Removal of excess sand and gravel.
(5) Examination of remaining heavy minerals.

Any procedure that accomplishes these operations will give you satisfactory results but most panners use some variation of the technique below. This is much easier to follow in a demonstration than to describe in words and you should watch a competent panner if you get the chance.

Some prospectors combine steps 1 and 2 by making a screen with ¼-inch to ½-inch holes and filling the pan through the screen. A screen is a great time and labour saver and well worth making. Some larger hardware stores stock metal cloth suitable for this purpose.

(1) Fill the pan with sand and gravel avoiding clay and coarse gravel or rocks. Fill the pan with water and stir, breaking up lumps. If this is done beneath running water the clay and mud will wash away in the current as you stir the gravel, otherwise use several changes of water until most of the clay or mud has been removed.

(2) Fill the pan with water, hold it level, and shake vigorously using a small circular motion (Fig. 11-23). The idea is to get every particle in the pan into motion and allow the gold and other heavy minerals to settle to the bottom of the gravel. If you do this properly the coarser pebbles and gravel will come to the top. Pick out any pebbles and remove coarse gravel from the top.

(3) Repeat step 2 but use slower circular movements gradually tilting the pan so that sand spills over the edge. If you use a traditional pan, do not allow the edge of the pan to tip down (Fig. 11-24) otherwise the heavy minerals may be lost. Hold it so that the edge has a slight upward tilt and allow the circular movement to

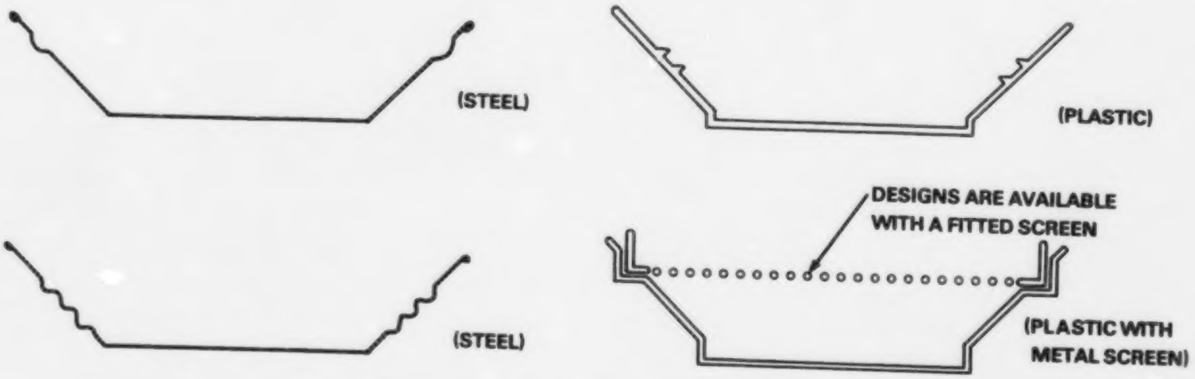

(STEEL)
(PLASTIC)
DESIGNS ARE AVAILABLE WITH A FITTED SCREEN
(STEEL)
(PLASTIC WITH METAL SCREEN)

Figure 11-22. Cross sections of modern gold pans.

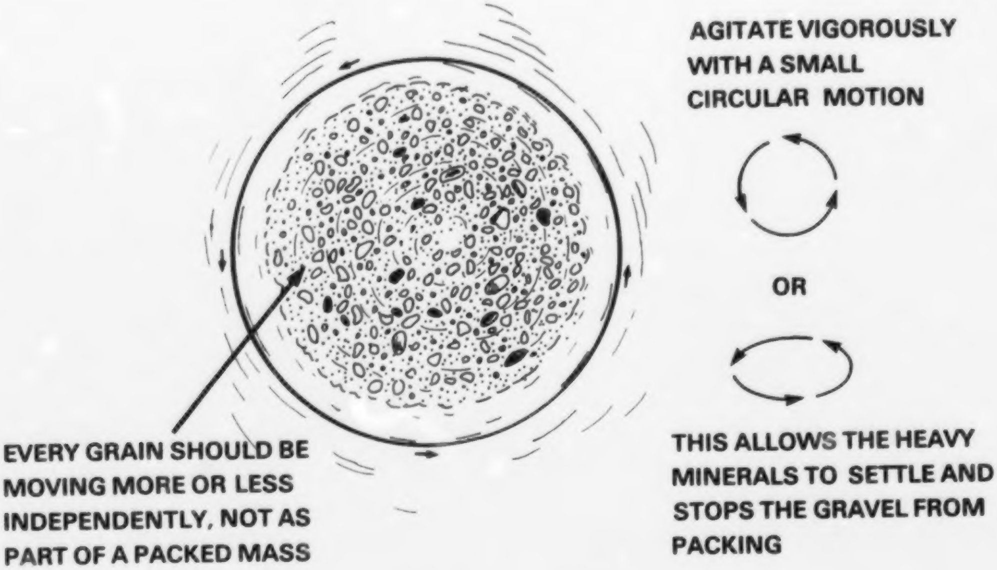


Figure 11-23. Settling the heavy minerals in a gold pan.

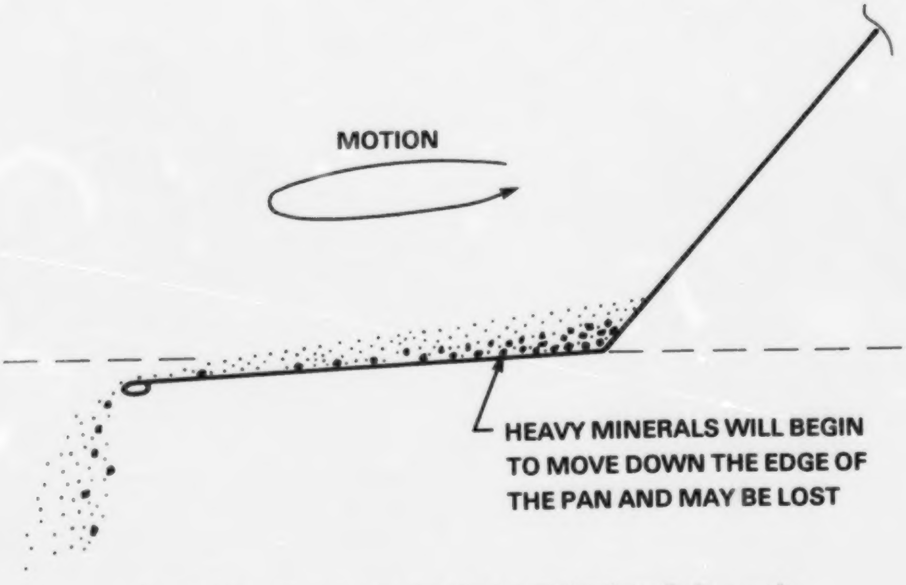


Figure 11-24. View showing one edge of a traditional pan tilted too much.

spill sand over the edge (Fig. 11-25). With a riffled pan you can allow the edge of the pan to tilt down — the riffles will catch the heavy minerals.

Repeat step 2 whenever any coarse gravel or stones come to the top, then step 3 again. As the amount of material in the pan decreases, the coarser material is removed so that the remaining material becomes finer.

(4) When you are left with a few spoonfuls of sand it may appear black (black sand) or dark red or brown (garnet). Add a little water to the pan and wash out the riffles so that all the sand is now in the bottom of the pan. Then hold the pan level and slowly swirl the water around the bottom of the pan (Fig. 11-26). This will spread the sand out, washing the lighter minerals

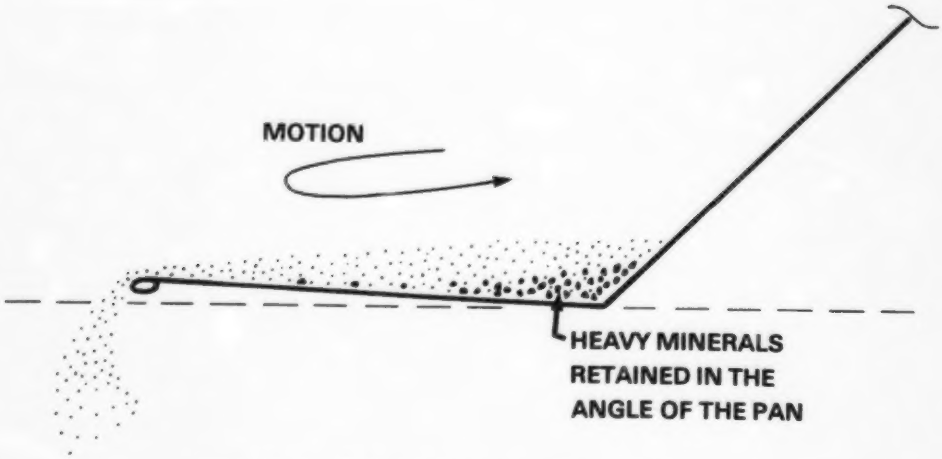


Figure 11-25. Traditional pan showing the correct tilt angle.

ahead of the denser minerals which will be left behind as a "tail". The tail can be examined with a magnifying glass.

Comments

(1) Panning is simpler and quicker if you can position yourself so that you can work with the pan partly below water with a gentle current away from the pan, not into it.
(2) Keep steel pans free of rust and all pans free of traces of oil or grease.
(3) The time required to process a pan of gravel depends on the result you are after. Most prospectors take more time and care than is necessary. If you merely want to find out if gold or sulphides are present, then it does not matter if you lose a colour or two, or some of the sulphide grains. An experienced panner can obtain this kind of information in a few minutes. If you want to get an idea of how much is present or if you are cleaning up a sluice then you must take more time and care.

2. UNITS OF MEASUREMENT

Historically, precious metals (gold, silver, and the platinum group) have had their own unique and usually awkward units of measurement. Many companies now use the metric system, some always have, but tradition in this field is very strong and you will need to know the current as well as the historical units, if only for research purposes.

Troy Weight System:

1 Troy pound = 12 Troy oz. = 0.83 English pound = 0.373 kg

1 Troy oz. = 20 Pennyweights = 1.097 English oz. = 31.10 g

1 Pennyweight = 0.055 English oz. = 1.56 g

Gold prices:

Gold prices are customarily quoted in U.S.$/Troy oz.
Price/Troy oz. x 0.032 = price/g

Historic Price of Gold (in U.S.$):
1792 — 1834 = $17.92/Troy oz.
1834 — 1934 = $20.67/Troy oz.
1934 — 1972 = $35.00/Troy oz.
1973 = $38.00/Troy oz.
post 1973 = $44.22/Troy oz. and up

Size Terms for Gold Particles:

Terms	No. of particles/ Troy oz.
Nugget (rarely "Rattler")	up to 200
Coarse	up to 500
Medium	up to 2 000
Fine	up to 12 000
Very Fine	up to 40 000
Flour Gold	over 40 000

Colours:

Colours are specks of gold. The term "number of colours", often seen in old reports, is the number of colours needed to have the value of 1¢. This was a useful way of comparing the value of gold particles when the price of gold was fixed but it is useless today. You may see the terms #1 colours, #2 colours, etc. This is a system that relates the weight of a gold particle to its size, which is easier to estimate. The scheme has never been widely used:

No. 1 colour = 4 — 10 mg = 0.75 to 1.0 mm diameter
No. 2 colour = 1 — 4 mg = 0.5 to 0.75 mm diameter
No. 3 colour = 1 mg or less = 0.5 mm or less in diameter

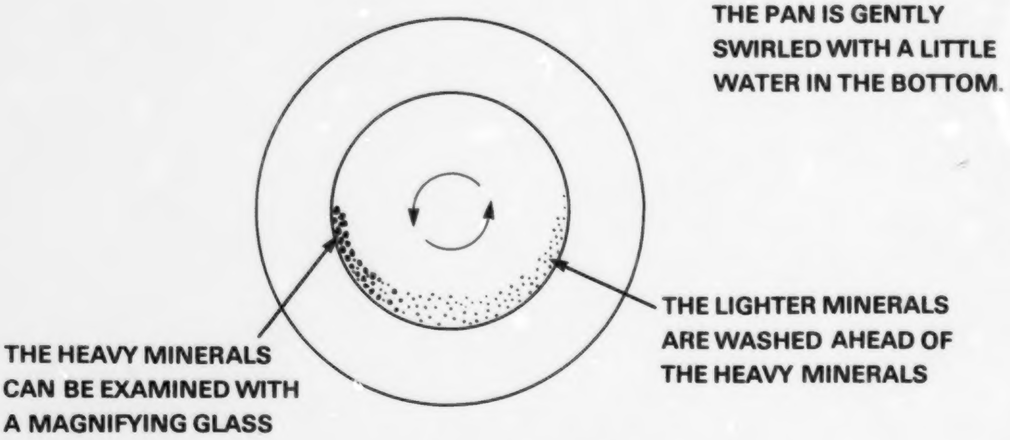

THE PAN IS GENTLY SWIRLED WITH A LITTLE WATER IN THE BOTTOM.
THE LIGHTER MINERALS ARE WASHED AHEAD OF THE HEAVY MINERALS
THE HEAVY MINERALS CAN BE EXAMINED WITH A MAGNIFYING GLASS

Figure 11-26. Examining the remaining heavy mineral concentrate.

Other Information:

1 cubic yard = 0.76 m^3

1 cubic yard of gravel weighs approximately 1 300 kg

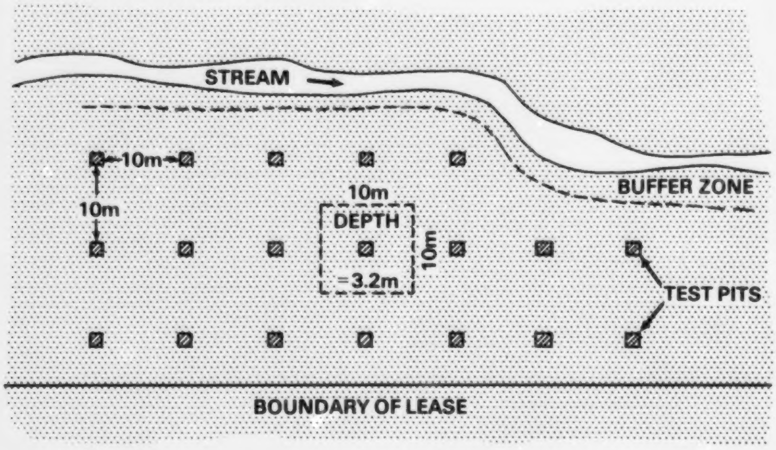
"Swell factor" for packed gravel = 20 to 25% — that is, dug gravel occupies 20 to 25 per cent more volume than packed gravel.

The "Pan Factor" =
no. of level pans/cubic yard = 180 for 16" pan
= 400 for 12" pan

1 ppm gold (part per million) = 1 g/tonne = 0.029 Troy oz./short ton

1 Troy oz./short ton = 34.28 g/tonne

3. SAMPLING A PLACER DEPOSIT (TEST PITS)



This is an idealized situation showing a regular pattern of test pits spaced 10 metres apart. The grade found in each test pit is assumed to extend halfway to the next test pit, and the depth of the block is assumed to be the same as the depth of the test pit.

(1) Map the location of the test pits and record the spacing.

(2) Number the test pits in some systematic manner.

(3) For each test pit record:
  (a) Number.
  (b) Depth.
  (c) Volume of gravel removed from test pit.
  (d) Weight of gold recovered from test pit.

Each test pit may be broken up into two or more sections which should be carefully separated and treated separately. The most common situation requiring this procedure would be overburden on top of placer gravel. It can also be done for gravels of different kinds, if there is evidence that gold values are restricted to a particular gravel zone. Be sure to measure each section carefully and have some systematic means of identifying each section, for example:

4a = overburden, 4b = silt, 4c = bouldery gravel.

Treatment of Test Pit Results

A sample calculation for a typical test pit follows — a spacing of 10 metres is assumed:

Test Pit No. 3

Depth = 5.0 m
Volume of gravel removed = 6.25 m^3
Gold recovered = 3.220 g

$$\text{Grade} = \frac{\text{gold recovered}}{\text{volume of gravel}} = \frac{3.220}{6.25} = 0.515\ \text{g/m}^3$$

Total volume of gravel assumed to have this value = area × depth = $10 \times 10 \times 5 = 500\ m^3$

Tabulate results, for example: Test Pit No. 3 = 500 m^3, grade = 0.515 g/m^3.

A sample calculation to find the average grade from six test pit results would look like this:

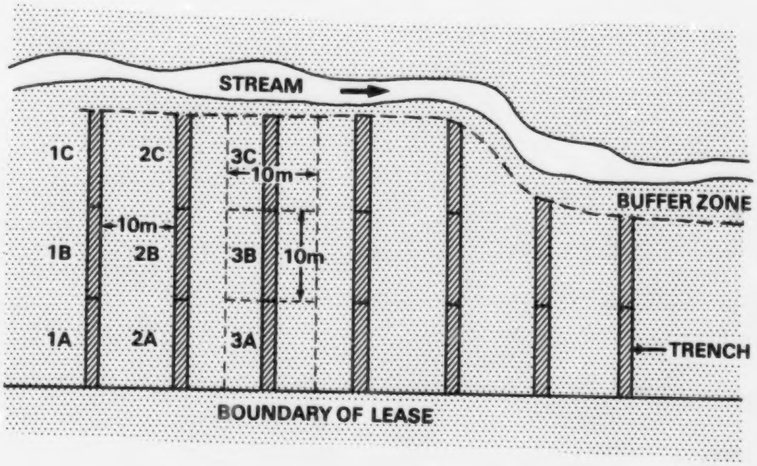
Test Pit No.	Volume of Gravel m^3	Grade g/m^3	Volume × Grade g
1	350	0.285	99.75
2	400	0.850	340.00
3	500	0.515	257.50
4	525	0.730	383.25
5	400	0.010	4.00
6	275	1.050	288.75

Total Gravel = 2 450m^3 Total Gold* = 1 373.25

$$\text{therefore Average Grade} = \frac{1\ 373.25}{2\ 450} = 0.56\ \text{g/m}^3$$

In practice of course, you will not be able to make money if the grade is below a certain value. There is clearly no point working the 400 m^3 of gravel covered by test pit No. 5, so you would leave it out of your mining plan. (You should put vehicles, equipment, and so on, on such ground). The calculation omitting No. 5 gives 2 050 m^3 gravel, average grade = 0.67 g/m^3.

4. SAMPLING A PLACER DEPOSIT (TEST TRENCHES)



This is an idealized situation showing a series of trenches spaced 10 metres apart. For additional information, each trench has been broken into 10-metre lengths. The grade found in each 10-metre length of trench is assumed to extend halfway to the next trench, and the depth of the block should be the same as the depth of the excavation, or the average depth of the trench if it reaches bedrock.

(1) Map the location of the trenches and record the spacing and length of trench segments.

(2) Number the trenches and the sections they are divided into in some systematic manner (see diagram).

(3) For each trench segment record:
  (a) Number.
  (b) Actual or average depth.
  (c) Volume of gravel removed from each segment.
  (d) Weight of gold removed from each segment.

It is possible to break up each trench segment into two or more sections, each representing different types of material, as was indicated for the test pits. Clearly this involves much more work and introduces more chances for confusion if not done very carefully.

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* Note that multiplying Volume of Gravel x Grade = Amount of Gold.

Treatment of Test Trench Results

The treatment of test trench results is essentially the same as for test pit results. The average grade for a number of trenches or trench segments is worked out in exactly the same way.

A sample calculation for a typical trench segment follows — the trenches are assumed to be 10 metres apart:

Trench Segment No. 4b

Average depth = 4.2 m
Length of segment = 10.0 m
Volume of gravel removed = 50.0 m^3
Gold recovered = 28.25 g

$$\text{Grade} = \frac{\text{gold recovered}}{\text{volume of gravel}} = \frac{28.25}{50} = 0.565 \text{ g/m}^3$$

Total volume of gravel assumed to have this value = 10 m spacing × length of segment × average depth = 420 m^3.

Tabulate the results, and proceed as for the test pit example.

5. OPERATING PITFALLS

The typical placer mining operation extracts and loads gravel into a screening device where oversized gravel and boulders are removed, then the undersized gravel is washed through a sluice. After passing through the sluice the gravel and sediment-laden wash water usually pass into settling ponds.

It is not the purpose of this chapter to consider the mechanics of placer mining in detail and beginners are strongly urged to contact their Placer Inspector or District Geologist for additional information. They may be able to obtain names of competent operators who will talk to visitors or answer questions about their methods and equipment.

Placer miners seem reluctant to learn from other miner's mistakes and the most commonly made mistakes, which can be seen year after year, are listed below:

(1) Inadequate or Improper Testing — This has already been covered in some detail.

(2) Failure to Recover Fine Gold — Generally too much gravel is passed through a sluice too quickly to recover fine gold.

(3) Too Large a Size Range Through Sluices — Gold, especially fine gold, cannot settle quickly through coarse material. The most successful operations seldom run any gravel larger than 10 millimetres (about 3/8 inch) through their sluices. Also, very few placer miners have any idea before they start mining of the size distribution of their gravel — the percentages of gravel of different sizes present. As a result screens are often not suitable for the gravel they handle. It is very easy to check the size distribution at the time you sample the deposit.

(4) Surges — Often a load of gravel is dumped through a sluice in a few seconds; no provision is made to spread this load out until the next load arrives. Gold cannot settle properly through what may amount to a load of mud.

(5) Infrequent Cleanup — As sluices become clogged with black sand and other placer minerals they lose their ability to trap gold. Frequent cleanups are a must, and sluices can be designed so that a cleanup takes no longer than two or three minutes.

(6) Inadequate Tailings Pond Capacity — Tailings ponds should be large enough not only to hold all the tailings from mining but also to allow the wash water to clarify. Some clay in wash water that is being recirculated is inevitable but many miners recirculate sand and silt-laden water, with consequent loss of fine gold through their sluices.

(7) Poor Equipment Maintenance — A third or more of placer operations at any given time are not operating due to mechanical problems. This is often the result of using old or worn-out equipment, having few or no spare parts on hand, plus a wait-until-it-breaks philosophy of maintenance.

(8) Lack of Planning — Many placer miners have no clear plan of action for the season. In 1983 one miner moved his tailings pond six times!

(9) Too Large a Scale of Operation — The really spectacular bankruptcies of the last few years have been, among other things, large operations. The majority of placer deposits are far too variable and unpredictable to supply the very large volumes of consistently valued gravel needed to support a large operation. Most successful placer operations are small ones, some processing no more than 100 cubic metres of gravel per day with modest-sized equipment, usually completely paid for, low operating costs and overheads. Small operations are flexible and can adapt quickly to changing conditions.

(10) Experimentation with Fancy Equipment and Ideas — The average placer miner lacks the engineering knowledge to design or evaluate new equipment or ideas. Beginners especially should stick to simple, tried, and proved procedures.

(11) Lack of Operating Funds — Many placer miners sadly underestimate the time it will take to set up their plant, iron out the bugs, and get it operating. It can also take one to two months to get a cheque back from a refiner. Placer mining is a business, and like any other business venture it will take time, perhaps two or three seasons, to get it running successfully.

(12) Theft — Unfortunately if you can get to your property so can other people. Leaving a set-up unsupervised is an open invitation to thieves.

CHAPTER 12 — PREPARING CLAIMS AND MAKING A DEAL

INTRODUCTION

This chapter contains suggestions for preparing your claims, and information and advice about "making a deal". Unfortunately prospectors are often ill-prepared for making a deal and as a result they may get far less for their properties than they are worth. If you look at a deal from a company's point of view, it simply does not make good business sense to offer you a dollar or a share more than you are prepared to accept. As a result, prospectors sometimes feel they have been treated poorly or unethically by a company when in fact they are merely victims of their own ignorance.

Making a deal is very much a market decision and the more you know about the market place the better your chances are of making a good one.

PREPARING YOUR CLAIMS

How much work should you do on your claims? No precise answer can be given to this question because so much depends on individual circumstances. Remember that the great majority of prospects, once explored, turn out to have no commercial value so that the more work you do, the more you run the risk of proving that your prospect fits this category! Apart from this consideration it is not your role to spend large sums of money on exploration. Remember, your role is to find mineralization, find enough to demonstrate that your prospect is worth exploring, and then let the mining or exploration company spend its money and do the exploring.

(1) Prepare your claims as if you will not be available to show a company geologist around. *If at all possible make yourself available* but if work or other commitments interfere, make sure that someone else can find everything you want him or her to see without difficulty. Unfortunately if you allow the occasional company onto your claims unsupervised they may attempt to explore your property before they have signed a deal. Then if they think it has no value they will say they are not interested and you have lost the chance of making a deal.

(2) Look your claims over as well as possible in the time you have. Take notes as you go and keep some kind of map of your claims with records of all areas of mineralization, locations of outcrops of interest, trenches, or any other physical worksites.

(3) Mark the features (step 2) clearly on the ground and flag access trails to any key feature that is not readily visible. Use different coloured flagging or paint to mark sampling sites and areas of mineralization, claim or grid lines, and access trails.

(4) If possible it is a good idea to take photographs of Legal Corner Posts, trenches, areas of mineralization, and other key features. Photographs of physical work will also help back up any assessment claims that you file.

(5) Take samples of both mineralized rock and wallrocks as well as samples of typical rocks occurring on your claims. Some companies favour certain rock types. Mark sample locations on the ground and on your map or in your notes.

(6) Take particular care with samples for analysis, and be sure to have records of assay results with you when approaching a company.

(7) Do not remove all the most spectacular samples from mineralized areas. Leave some of the good stuff in place for company geologists to see.

(8) Arrange to have different company geologists view the claims at different times.

WHO TO APPROACH

This is a much discussed matter among prospectors. Everyone seems to have stories, usually bad, to tell about this or that company. For a start your District Geologist will usually know of reputable companies who are actively looking for properties and what types of properties they are more likely to be interested in. You can also check the advertisments in the major trade publications such as the *Bulletin of the Canadian Institute of Mining and Metallurgy* and the *Northern Miner*.

Major mining companies are usually (but not always) interested in particular types of deposits or potentially large deposits. The major companies are more likely to have the expertise, the money, and the backing of a good business reputation, and any payment involving shares is much more likely to be marketable. Junior mining or exploration companies on the other hand are more likely to be interested in the smaller deposits. However, few of them have the resources to put a property into production should the need arise, and most will sign a deal with a major company if they find anything promising. This is the way most of the successful junior companies make their money. As a result of any second deal your interest in your property may be reduced.

Before approaching any companies you would be wise to check into their backgrounds, see how long they have been in business, what their assets are, whether their shares have been traded, and for how long, and generally see what sort of track record they have. Stockbrokers should be able to provide you with this kind of background information.

Be prepared to approach several companies and possibly to be turned down several times before you find someone interested. Timing may be important. Many deals are signed before the field season when exploration budgets are being allocated for the year and also at the end of the field season or fiscal year, when unspent or leftover funds may be available. Major companies, however, can usually find money for a good property at any time of the year.

THE FIRST CONTACT

Your first contact with a company geologist is likely to be by phone or by a visit to the company office. In the former case if the company is interested, this will be followed by a meeting, perhaps at your home or a hotel room. The company will want to look you over before looking at your property.

Here are some points to help you make a good impression and make that first meeting a success.

(1) Have all your papers and maps organized and ready. These should include a map showing the location of your claims, your claim registration papers, any maps you have prepared showing locations of mineralization, sample localities, assay results, photographs of mineralization, and other data.

(2) Have your specimens ready and properly labelled or numbered.

(3) Be ready to explain what you have found and where.

(4) Answer any questions as accurately and honestly as you can. Do not exaggerate but be positive and do not dwell on any negative aspects of your property.

(5) Ask your own questions; you may learn something of value about the property or the company you might be dealing with.

(6) You may be asked what you want for the property so give this matter some thought. Details of any offer or deal should be discussed only after the property examination but the geologist may want to know whether your expectations are realistic before spending money on an expensive helicopter trip for example. Give only a general answer at this time such as "I'd like a working option with some cash up front" or "I'd like to sell the claims for the best cash offer I can get". Do not commit yourself and avoid mentioning any dollar figure, even a "ballpark" figure, at this stage unless you have some experience of the market and what it will bear.

(7) The costs of making a property examination are usually paid by the company. If they cannot afford to do this it is unlikely they can afford to make a good deal.

ON THE PROPERTY

It is rare for a property examination to take more than one visit. The geologist will try in that one visit to look over your claims, get an idea of the type and extent of any mineralization, and decide whether your property is worth the company exploring it.

Legally, a geologist can do little more than look without your permission but obviously he or she is going to expect to make a proper examination of your property. It will be assumed that outcrops and mineralization can be examined and that specimens and samples can be taken. The geologist will also expect to verify any statements you have made about the property.

This does not mean, however, that you should allow a geologist to do anything he or she wants. For example, if you have found some mineralized outcrops in the centre of a soil geochemical anomaly, the geologist will expect to be able to take soil samples to verify the anomaly. You would be unwise to allow him or her to do geophysical tests. If you have sampled a vein in outcrop and trenches the geologist will expect to do the same but should not be allowed to take a sack full of soil samples. Basically you want your property to be *examined* and you want to create a favourable impression but you should not allow it to be *explored* until after a deal is signed.

Again, do not be afraid to ask questions. You can often get a feeling for the experience and ability of the geologist, or the attitude of the company by asking questions.

After the property examination do not expect the geologist to give you an immediate "yes" or "no" about making an offer. Almost certainly the company will have to wait for assay results before making a decision and a junior geologist will have to report to seniors, but you should not be kept waiting indefinitely. Ask the geologist when you can expect a decision and if you have not heard from the company by the stated time, call them.

Regardless of whether the company makes you an offer or not you should as a courtesy receive copies of assay results from any samples taken from your property.

TERMINOLOGY OF A DEAL

Deals between prospectors and companies have a legal jargon of their own. Here are some explanations of the more important legal terms you may encounter.

AGREEMENT

An agreement is a "deal". It is an arrangement to prospect, explore, develop, buy, sell, or option a property. It can take many forms.

Grubstaking Agreement — The grubstaker agrees to finance or equip a prospector in return for an interest in anything staked. The key is to have all the details spelled out, particularly the dates the agreement is to start and expire, the funding involved, the work expected of the prospector, and the extent of the prospector's interest.

Option Agreement — This is an agreement with a company or another party who can exercise certain options and increase their interest in a property by making periodic payments to you or by exploring, developing, or producing from your property. The most common are **Options to Purchase** and **Working Options**.

Prospecting Agreement — This is an agreement relating to prospecting only.

Sales Agreement — This is an agreement to sell part or all of your interest in any property. A form for this purpose, called a **Bill of Sale**, is available from any Gold Commissioner's office or Sub Recorder's office.

A sale may be incorporated into other agreements such as working options. Under current British Columbia law assessment work done on a property can only be filed by the *owner*. In order to get around this problem if a company is doing work on your property, it is usual for you to sell the property to the company, and for them to sell it back to you for a nominal sum if they drop the option.

This will all be spelled out in the agreement and should cause no problems when dealing with a major company, but a junior company could go out of business halfway through an option and there might not be anyone around to sell your claims back to you. A common way to avoid this problem is to get a signed but undated bill of sale transferring the property back to you. This is deposited with a lawyer or trust company for use if the junior company goes "belly up".

Syndicate Agreement — "Units" in a syndicate are sold. In return for money the prospector undertakes to prospect and stake anything of value that is found. Buyers of units get an interest in the claims according to the terms of the agreement. Syndicate agreements may be subject to possible securities regulations. Like a grubstaking agreement, make sure all the details are spelled out.

Partnership Agreement — This can be a formal or informal arrangement for prospecting, grubstaking, etc. The key is to know your partner! A formal partnership is subject to British Columbia law regarding assets, liabilities, and so on.

BUY-OUT

Many agreements contain some sort of buy-out clause giving a company the option of buying the prospector's interest in a property for a specified sum of money or number of shares. Often a prospector's retained interest is subject to a sizeable buy-out clause if the property goes into production.

ESCROW

This is an agreement whereby a Trust Company holds a prospector's interest (usually shares). Shares held in escrow can only be sold in specified numbers and on specified dates, and escrow agreements are prescribed and controlled by stock exchange authorities.

EMPLOYER/EMPLOYEE RELATIONSHIP

This relationship may exist if you work for a salary or under the direction or supervision of someone else.

INDEPENDENT CONTRACTOR RELATIONSHIP

This may exist if a prospector is free to work without direct supervision. Prospectors sometimes work on their own or someone else's claims and are paid by another party. Different tax, insurance, Workers' Compensation, and other rules apply depending on whether an Employer/Employee relationship or Independant Contractor relationship exists.

INTEREST

An interest is a piece of the pie. It can take many forms.

Carried Interest — This is an interest in a property that is carried through exploration, development, and so on with no strings attached, and regardless of second or third deals. This is worth a try to get; carried interests are not as rare as they once were. A carried interest must be very carefully worded in any agreement.

Interest Dilution — This means the reduction in your interest as a result of such things as the sale of more units of a syndicate, the issuing of more shares by a company (if your interest is in shares), or the signing of a second deal involving your property. This last situation requires an explanation. Suppose your interest in a property at the end of an option agreement is 5 per cent of any profits the company makes from the property when they put it into production. They may have to sign a deal with another company to get production funds, retaining only a 10 per cent interest themselves. So now instead of 5 per cent interest you get 5 per cent of the 10 per cent or only 0.5 per cent!

Interest in Profits — This is an interest in any profits made as a result of production from your property. The usual form of this is **net profits interest** which means profits after deduction of expenses. The problem here is to define legitimate expenses. If this is not done in detail and with great care, a prospector could find all kinds of expenses being deducted from profits leaving very little "net" for the prospector to share in.

Participating Interest — Generally you should avoid this unless you have direct control over all spending, which is most unlikely. Others who have participating interests may run up big bills and if they go bankrupt or disappear, you may end up having to pay a portion or all of their debts. You may also be required to provide funds for any exploration or mining in proportion to your participating interest!

Retained Interest — This term usually describes the interest you are left with at the end of a deal. Thus you might retain a 5 per cent net profits interest at the end of an option agreement. Beware of companies wanting to retain an interest in your property if they work on it and then drop it. This is common practice in the oil industry but causes problems in the mineral industry. A company wanting to make a deal with you would also have to negotiate with any third party holding a retained interest. This complicates the situation and could greatly reduce your chances of getting another deal.

Royalty Interest and Advance Royalties — A royalty interest is tied to some production unit such as tonne of concentrate or ounce of gold produced. A common form of royalty interest is based on the **net smelter return.** Unlike the net profits interest the net smelter return is fairly easy to define.

In the majority of situations the net profits interest will be to the advantage of the company and the net smelter return will be to the advantage of the prospector. Tax laws are different for money received from royalty interests and profit interests and this could also affect the prospector's "bottom line".

Advance royalties are royalties paid before production starts. If advance royalties are paid the company usually deducts them from royalties due when production does start, until all advance royalties have been covered.

Major companies with several operating mines may be in no hurry to start up another one. Thus you could have a production decision made on your property but with no startup date set and with no money coming in possibly for many years. Advance royalties discourage companies from "sitting on" your property and provide some income while the company makes up its mind about production. The company may offer a buy-out clause as an alternative to advance royalties.

LETTER OF INTENT

After negotiations have been concluded but before a deal is signed, the prospector and the company may sign a letter of intent. This should state that both parties intend to sign a deal containing the features agreed to during the negotiations, on or before an agreed-on date. This gives both the prospector and the company some legal protection while the language or other details of the final deal are being worked out.

There should be no problem with a letter of intent from a major company but check all letters of intent carefully as some are in fact agreements. Once signed the company may drag its feet about replacing it with another document indefinitely, and use the general and incomplete language of the "letter" to get away with all kinds of liberties or abuses. Moreover there might be very little the prospector could do about it. Beware of anything in a letter of intent that suggests it might be an agreement such as phrases like ". . . this agreement is binding . . ." or ". . . if you accept the terms of this agreement . . ." or of letters with no deadline date for replacement by a formal agreement.

SECURITY

Always have this spelled out. It could be shares, money, the title to your claims, or the shirt off your back.

OPTION TO PURCHASE

This is an agreement to purchase an interest, often 100 per cent, by installments as a rule. The purchaser has the exclusive right to investigate your property as he sees fit and decide whether to drop the option (and lose all interest) or continue with the payments. The problem with options to purchase is that you lose all control over the purchaser's actions. He may just pay one or more of the installments but do no work. If he drops the option you may have no work done for your information or for assessment purposes.

WORKING OPTION

This is an agreement to do specified exploration work or spend a specified amount on exploration, usually in several stages. It can take a number of forms; a common one involves increasing cash payments to the prospector and increased expenditures by the company at each stage. In return the company increases its interest in your property. Working options usually cover several stages through to production but as you might expect, most working options are dropped by the company in the early stages.

Because working options are a common form of a deal some Additional Notes have been included. Many points covered by these notes will also be of value in negotiating other kinds of deals.

MAKING A DEAL

INTRODUCTION

In making a deal you have to strike a balance between asking for too much — possibly ending up with nothing — and getting less than your property is worth. A good deal requires two things: first, you must have some idea of what sort of deals are currently being made, and second, you must have some idea of just how good your property is.

Information on current deals may be found in trade papers such as the *Northern Miner*, and investment publications such as the *George Cross News Letter*. Your District Geologist may also be able to give you some information.

Knowing how good a property is takes experience, and even then you cannot be certain. Some companies will walk away from properties that other companies will fight over.

THE STANDARD FORM

Many companies have a standard form for such deals as options to purchase and working options. There is a psychological advantage to such forms for the company. A geologist or other official usually has authority to fill in blanks with your name, details of your property, and so on, as well as to write out a cheque for any cash "up front". You are offered a completed package with no troublesome negotiations, no hassles, no delays, no uncertainties.

The sight of a cheque with your name on it for more money than you may have seen for some time may well tempt you to sign the deal. Also, if there is some feature of the deal you do not like, the company official can say, with some truth, that it may be time consuming or costly to get lawyers in to change the language, or that senior company officials may not agree to any changes. You will have to decide whether to press for changes under such circumstances.

A standard form from a major company *should* be one that has gained some acceptance among prospectors over the years and you may decide to accept it, even if it does not have every feature you might want. However, you would be advised to have a lawyer examine documents from any company before you sign them.

Lawyers who have the expertise to advise on options and other agreements are few in number. Most work in Vancouver and their fees reflect the specialized nature of their work. Nevertheless it could be money very well spent.

THE NEGOTIATED DEAL

If a major company agrees to negotiate the terms of a deal they may suggest a lawyer to look after your interest and may even pay your legal fees for you (there is no harm in asking!). Most junior companies will expect you to pay for your own legal costs. You should be very clear what you want to try for in the negotiations. You do not want to have to pay a lawyer to sit there while you make up your mind about some point or other.

GENERAL TIPS

(1) Prospectors are often advised to seek cash for a property if they do not feel it is particularly good and to go for a working option for any property they feel is really good. As an alternative to a cash sale you could try for a working option with modest terms.

(2) Prospectors are invariably advised to seek as much money "up front" as they can get in an option agreement, rather than seeking possibly attractive later provisions. This obviously is because very few option agreements get beyond the first or second year.

As a suggestion you should seek:

(a) Enough money to recover all costs of prospecting and staking the property, costs of any work done on the property since staking, plus any legal fees.

(b) Enough money to finance another season of prospecting.

(c) Anything extra you can get.

(3) Companies do not like details of offers they make to be released to other companies. It is acceptable to say, "I have received an offer from another company with more money up front", but do not say "the Midnight Mining Co. has offered me $15,000.00 up front".

(4) "Play it straight" and do not stretch the truth or you might lose a deal. You could also get yourself a bad reputation with a company or the industry.

(5) Be careful about making verbal or other promises unless you are determined to keep them. Changing your mind could get you into legal trouble.

(6) If you have received an offer from a company that you are inclined to accept, you should contact any company you have not yet heard from to give them a final opportunity to respond.

(7) If you have accepted an offer from a company and then get a better offer from another company, changing your mind may be legally impossible. Just grit your teeth and tell them they are too late. They may be more prompt with an offer on your next property!

(8) An option agreement that is dropped by a company in the early stages may not mean the end of your property unless results are completely negative. A property that has had some money spent on it with mixed results may be attractive to a second company. It is not unusual for a property to be optioned two or more times.

CONCLUSION

These few pages on legal jargon and making a deal should give you some idea of the more common features of various types of agreements. They are not intended as a substitute for legal advice, nor do they cover other features that might occur in an option or other agreement. Deals involving payments in shares instead of cash in particular have not been considered in detail. Some major companies will offer shares as part of a deal, especially if a property reaches the production stage. Junior companies commonly offer shares in deals.

Such deals are more complex and have many potential problems or pitfalls for the unwary prospector. If you receive an offer involving shares with a potentially high "paper" value you should have a lawyer at least check the documents and explain them to you.

Finally, when that happy day arrives and you receive the first cheque or share certificate remember that sooner or later the tax collector is going to want to share in your happiness. Tax rules relating to income from prospecting, especially if shares are involved, are quite complex, and seem to get more complex every year. You would be well advised to have an accountant or a competent investment adviser work out the best way for you to get the most out of your deal, and explain any potential tax problems to you. Nevertheless I hope that some day you will have to deal with such problems!

ADDITIONAL NOTES

WORKING OPTIONS

As a prospector make sure the following items are included, or try to have them included in any agreement:

(1) Access to Your Property While Under Option — You should be able to see what is going on at any reasonable and mutually agreeable time. Also you should be able to see maps, core, or technical data, such as assay results, obtained by the optioning company. The company may require you to sign an **oath of secrecy** before allowing you access to such information and you could also become what the stock exchanges call an **insider**, and subject to restrictions on buying or selling shares of the company.

(2) Additional Claims — Any additional claims staked by the company that adjoin your claims should become your property if the option is dropped. You may not get this but it is worth trying for. Commonly a limiting distance of 1 or 2 kilometres from your claims is applied to such additional claims.

(3) Assessment — The company should record the maximum amount of work that can legally be recorded for assessment purposes on your property and not charge it to its own P.A.C. (Portable Assessment Credit) account.

(4) Cash Payments — Cash payments to you should increase each year. Cash payments in the last years of a lengthy option agreement may be very large — a million dollars or more! Do not let the promise of such payments alone tempt you to sign a deal, and do not get too excited if they happen to be in any deal you do sign. The company has no intention of paying out such sums of money — they will either drop the option or make a production decision before such payments are due.

(5) Equipment — The company should remove any equipment or supplies from the property before dropping the option. If they do not do this you should have the right to require them to do this or to take ownership of such items if you choose. While the company is unlikely to overlook that D-9 tractor, you might inherit camp gear, supplies, or other useful items.

(6) Legal Requirements — The company should be responsible for all permits, bonds, reclamation, and other work required during the period the option is held, and it should discharge any legal obligations resulting from the work it does, before dropping the option and returning the property to you. Clearly you do not want to have to clear up any mess left by the company to satisfy Ministry of Environment or other officials when you get your claims back.

(7) Legal Status — The company must maintain the claims in good standing at all times and keep them free of any liens or charges.

(8) Option Termination — The agreement should terminate *automatically* if option payments are not received by a specified date. Copies of any maps, assay results, core logs, or other technical data prepared during the option should also be handed over within a specified time of the option being dropped.

(9) Period of Good Standing — You should insist that all claims are kept in good standing, by cash payments if need be, for at least one full field season after the option is dropped. The reason for this is that if the claims are in good standing until February, and the option is dropped in December, you may not be able to do any assessment work on them and could lose them if you cannot afford to pay cash in lieu of work.

You or the company may wish to consider the following provisions — but usually for different reasons:

(1) Extension Clause — You or the company may wish to extend the length of the agreement. The company might not be ready to make a production decision at the specified time, and you might not wish to force the company to drop the option under such circumstances. Needless to say you should put a price on any extension.

(2) Sale or Assignment of Interest — You should have the right to sell all or part of your interest as you see fit, although it is unlikely you would want to do so if the option is progressing satisfactorily. However, if the company wishes to sell all or part of its interest, you should insist that the new interest holder carries out the provisions of the option as if it had signed the option with you in the first place.

(3) Work Requirements — If dollar values of work are spelled out they should increase significantly every year, like the cash payments. Some companies are reluctant to agree to specific work requirements. They might argue that this could force them to drop the option if funds are "tight" one year, or if severe weather prevents them from spending the required funds, and so on.

Prospectors are divided on this point. Some want to make sure work is done on their property. Some feel that the increasing cash payments will force the company to do work on their property, while others do not care what work the company does as long as the cash payments keep coming in.

(4) Default Clause — If the company fails to complete specified work or other requirements then the option should terminate. However there are a variety of default clauses that allow a company to delay or renegotiate work requirements. While these may allow you to keep an otherwise satisfactory company working on your property they could also make it difficult to get rid of a poor performer.

Needless to say, the company will also expect or insist on certain things from you before signing an agreement. The most likely are as follows:

(1) Spokesman — If more than one person has an interest in the property, as in a partnership, the company will usually insist on negotiating with one person duly empowered to speak on behalf of all those having interests. You may have your lawyer act as your spokesman after consulting with you or else those having interests should write out and sign a **power of attorney** allowing one of the group to negotiate on their behalf.

(2) Staking and Ownership of Claims — The claims must be properly and legally staked and recorded and no other person other than yourself or those you are empowered to represent must have any interest in the claims.

(3) Liens and Encumbrances — The claims must be free from all liens, disputes resulting from or related to Section 50 of the *Mineral Act*, and encumbrances. An unpaid bill to a back-hoe operator for digging a couple of trenches, for example, is an encumbrance.

(4) Standing — The claims must be in good standing when you negotiate a deal.

(5) Right to Restake — A company may wish to abandon some claims, add to the existing claims, or to restake the area, particularly if you have staked 2 Post claims, or if any defective staking is discovered. Obviously you should ensure that you will have exactly the same interest in any restaking as in the original staking, and that restaked claims will be subject to the same conditions as before.

As you can see, it is vital that you do your staking and recording as carefully as possible. Any misrepresentation, unintentional or otherwise, could cost you your option, and possibly expose you to legal action by the company.

ADDITIONAL GENERAL INFORMATION

The following items may be purchased at the addresses indicated:

(1) Federal Government Topographic Maps, Geological Survey of Canada Maps, Bulletins, and Other Publications:

Geological Survey of Canada
100 West Pender Street
Vancouver, B.C.
V6B 1R8

(2) Mineral Assessment reports, maps and indices; and agent for Crown Publications Inc. for distribution of geological reports and maps:

B.C. & Yukon Chamber of Mines
840 West Hastings Street
Vancouver, B.C.
V6C 1C8
Tel: (604) 681-5328
FAX: (604) 681-2363

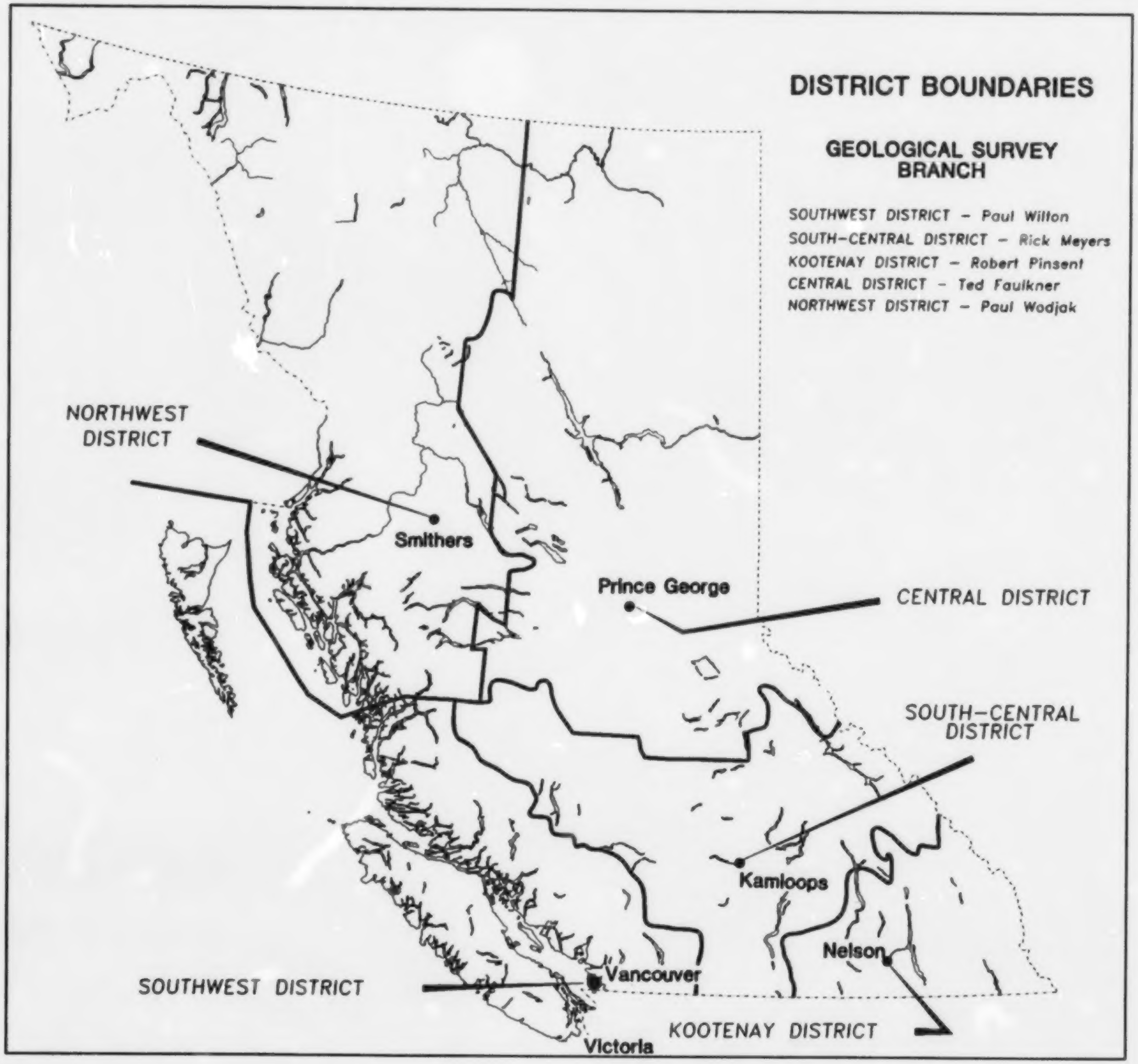
(3) Ministry of Energy, Mines and Petroleum Resources, Geological Maps, Bulletins, and Other Publications:

Crown Publications Inc.
546 Yates Street
Victoria, B.C.
V8W 1K8
Tel: (604) 386-4636
FAX: (604) 386-0221

(4) Free Miner Certificates may be purchased at any Provincial Government Agent's, Gold Commissioner's, or Sub Recorder's office.

(5) Claim tags may be purchased at any Provincial Government Gold Commissioner's or Sub Recorder's office.

In addition, Provincial Government Agents and some private businesses in the larger cities also sell Federal or Provincial Government topographic maps. These maps are usually restricted in coverage to the local region, and they may not be available in all scales.



1 Northwest District,
Bag 5000
Smithers, B.C. V0J 2N0
847-7387

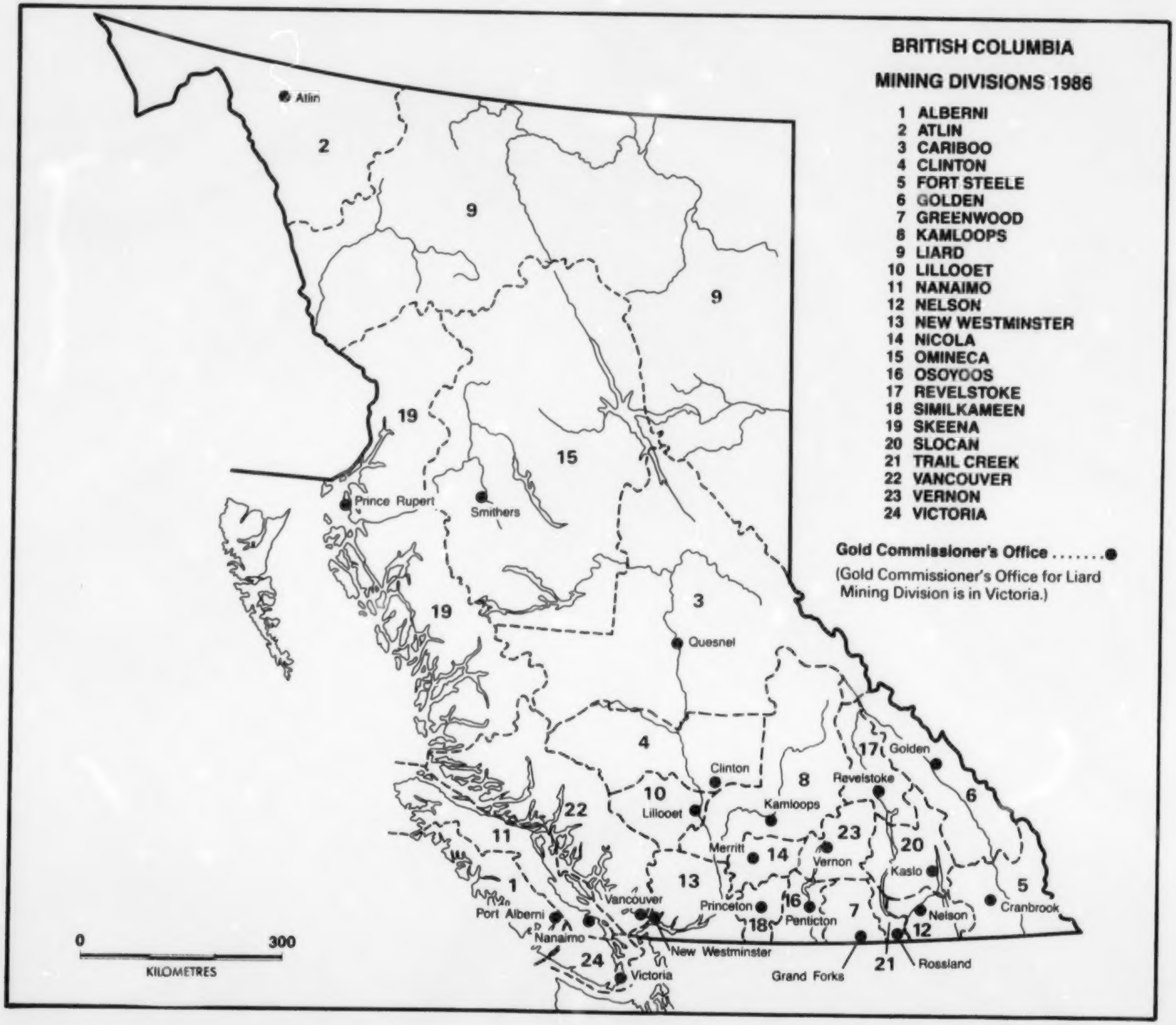
2 Central District,
1652 Quinn St.,
Prince George, B.C. V2N 1X3
565-6125

3 South Central District,
101, 2985 Airport Dr.,
Kamloops, B.C. V2B 7W8
828-4566

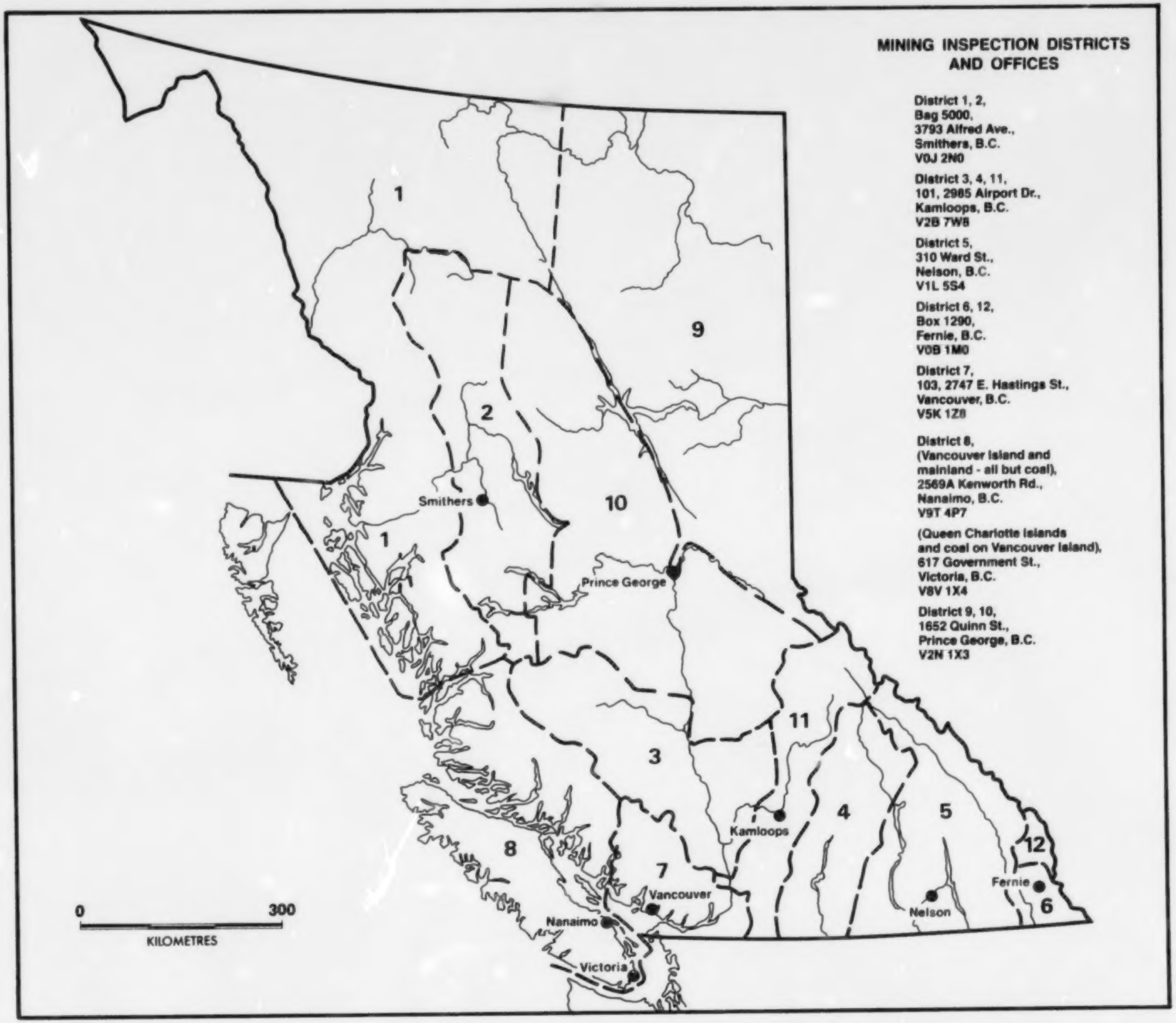
4 Vancouver/Southwest District
301, 865 Hornby St.,
Vancouver, B.C. V6Z 2C5
660-2780

5 Kootenay District,
310 Ward St.,
Nelson, B.C. V1L 5S4
354-6132

District geologists' areas and offices.



Mining divisions.



MINING INSPECTION DISTRICTS AND OFFICES

District 1, 2,
Bag 5000,
3793 Alfred Ave.,
Smithers, B.C.
V0J 2N0

District 3, 4, 11,
101, 2985 Airport Dr.,
Kamloops, B.C.
V2B 7W8

District 5,
310 Ward St.,
Nelson, B.C.
V1L 5S4

District 6, 12,
Box 1290,
Fernie, B.C.
V0B 1M0

District 7,
103, 2747 E. Hastings St.,
Vancouver, B.C.
V5K 1Z8

District 8,
(Vancouver Island and
mainland - all but coal),
2569A Kenworth Rd.,
Nanaimo, B.C.
V9T 4P7

(Queen Charlotte Islands
and coal on Vancouver Island),
617 Government St.,
Victoria, B.C.
V8V 1X4

District 9, 10,
1652 Quinn St.,
Prince George, B.C.
V2N 1X3

Mining inspection districts and offices.

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